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REPORT

OF THE

GEOLOGICAL RECONNOISSANCE

OF THE

STATE OF VIRGINIA.

MADE UNDER THE APPOINTMENT OF THE Virginia BOARD OF PUBLIC WORKS.

BY WILLIAM B. ROGERS,

PROFESSOR OF NATURAL PHILOSOPHY IN THE UNIVERSITY OF VIRGINIA.

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OFFICE OF THE BOARD OF PUBLIC WORKS,
11th January, 1836.

TO THE HOUSE OF DELEGATES:

I have the honour to transmit herewith a report of the geological reconnoissance made in the state of Virginia during the past year, by Professor Rogers, of the University of Virginia, whose reputation as a geologist and chemist induced the board without hesitation to appoint him to make the said reconnoissance.

The report is accompanied by a map, exhibiting a profile and physical section of the country from tide water to the Ohio.

I am, very respectfully,

Your most ob't serv't,

LITT'N W. TAZEWELL,

President of the Board of Public Works.

REPORT.

GENTLEMEN,

I beg leave to present the following report of the geological reconnoissance of the state of Virginia, authorized by an act of the legislature, bearing date March 6th, 1835, with the execution of which I have had the honour to be entrusted.

In the prosecution of this duty, while my attention has not been withheld from such observations of a minute and detailed description as opportunities occasionally threw in my way, it has been chiefly directed to the legitimate objects of such a reconnoissance, namely, the general geological and mineralogical features of all the important divisions of our territory, with a view to exhibit the benefits to be derived from a detailed survey, and the mode of conducting it best adapted to develop the structure and resources of the state. Although in the course of these inquiries many new observations have been made calculated to prove extensively advantageous, numerous matured discoveries were not to be anticipated, considering either the design of the reconnoissance or the very general nature of the investigations which are appropriate to an examination strictly preliminary in its character. Inquiries of a more minute description, extended to all the divisions of the state, would obviously have been impossible, and until some scheme of systematic investigation in detail is put in operation, comparatively of little value. With such views, it is thought that the objects of the reconnoissance are accomplished, in exhibiting the prominent geological features of the great divisions of the state, the more important natural resources dependent upon their mineral structure, and in pointing out in relation to each the various desiderata to which future inquiry may be beneficially directed.

MODE OF CONDUCTING THE RECONNOISSANCE.

With the view of exhibiting clearly the geological structure and relative extent of the various formations in the state, as far as ascer-

tained during this reconnoissance, it was important to construct what is termed a geological *section* or *profile*, from actual observations made from point to point in one or more lines transverse to the general ranges of the strata; thus combining in one view, all the most important mineral formations of the state, together with their prevailing order of succession, and their relative inclinations, or the angle in which each inclines to the horizon. The general line of observation selected for this purpose, extends from Hampton Roads to the mouth of Guyandotte. A belt of country of variable breadth, spreading to some distance on either side of this line, was the more immediate subject of investigation, and furnished the materials from which the geological section appended to the present report was constructed.

In prosecuting the examinations necessary for this purpose, no one line of observation was rigorously adhered to, but numerous local profiles were first formed, and thence by a reference of them all to the general line already specified, the entire profile was formed, which is now presented. It is, therefore, tendered at this time only as an approximate delineation of a transverse geological section of the state, and as such, though sufficiently accurate for the purposes of occasional reference in the present report, lays no claim to the minute precision of geological profiles constructed from the accurate data of a *detailed survey*. Several minor belts also transverse to the general ranges of strata, and remote from the former, were likewise examined, and particular profiles constructed from the data thus obtained. One of these extends in a general direction from the White Sulphur springs, by Covington and Lexington to Buckingham courthouse; a second from Columbia, by Charlottesville, Turk's and Rhodes' gap, and Harrisonburg, to the North mountain; and a third embraces a portion of the Potomac. In addition to these transverse lines of observation, several routes have been explored more nearly conforming to the bearing or direction of the strata. One of these extends in a general direction from Halifax, on the Roanoke, to the lower falls of the Potomac, and is nearly coincident with the western boundary of the tide water or tertiary section of the state. Another embraces a general view in the longitudinal direction of the valley of Virginia, from the Potomac to the James river, &c. Beside these, many other lines of observation were examined, some of them embracing a distance of 50 or 60 miles, on either side of the general route. Keeping in view the im-

portant practical inquiries appertaining to the reconnoissance, as much local information of a useful nature has been obtained on each excursion, as was consistent with the time which could be devoted to investigations of a special character. The general nature of the observations contemplated in the reconnoissance, and the necessity of rapid movements when so great a breadth of formations was to be traversed, rendered much delay in minute local observations inexpedient, on which account many points of great practical interest will be excluded from the report, which might otherwise have been introduced. These would be among the proper subjects for inquiry in a detailed survey.

In regard to the tide water section of the state, it is proper to remark, that through some previous attention to its geology, I am enabled to present a somewhat minute account of its important features, as observed in several large and interesting districts which I have explored. Among which, I would specify the peninsula bounded by the York and James rivers, and many of the counties on either side. More recently, and in connexion with the reconnoissance, I have examined the country on both sides of the Pamunkey, from the junction of the North and South Anna to its mouth, and have extended my inquiries with some success into similar formations south and north as far as the James river and the Potomac. The discovery of a material likely to prove valuable to the agriculture of that section of the state, may, without impropriety, be referred to as an illustration of the utility to be expected from minute geological inquiries, directed to every portion of our territory.

But in addition to the duty of exploration performed according to the plan which I have now described, I have devoted some time to the chemical analysis of rocks, ores, earths, marls and mineral waters. In relation to this department of my duties, however, it is easy to perceive, that the tedious nature of such investigations, would preclude the completion of many accurate analyses within the period allotted to the reconnoissance; but a variety of useful chemical results have been obtained, which as far as compatible with the scope and objects of this report will be detailed in the following pages.

GENERAL GEOLOGICAL DIVISION OF THE STATE.

For the sake of exhibiting under one view, each group of analogous formations, the whole territory of the state may be conveniently

divided into five principal regions. These we will treat of in a geographical rather than geological order; first defining the limits of each respectively, with as much precision as in the imperfect state of knowledge on the subject can be attained, and then in general terms describing the geological features by which they are, to a certain extent, severally distinguished.

(1.)—The first of these, which may be called the ***tertiary marl region***, embraces nearly all that portion of the state included between its eastern boundary, the Chesapeake bay and the Atlantic, and a hypothetical line intersecting the principal rivers at their lowest falls. Various beds of clay and sand, nearly horizontal in position, abounding in fossil shells, and the remains of large marine animals, form the characteristic strata of this division of the state, while occasional bands of iron ore, and beds of green sand, and a small portion of gypsum, occurring in connexion with one of the fossiliferous deposites of the region, are among its other materials of value.

(2.)—The second division is comprised between the hypothetical line above mentioned and the western flank of the *Blue Ridge*—including under this title the range very improperly denominated the Alleghany mountain in Franklin and Patrick counties. According to the delineation of Mr. M'Clure, by whom the first attempt was made at marking out the great geological divisions of North America, the rocks of the Blue Ridge and a narrow adjacent belt of territory should be regarded as belonging to the primary system of geologists—while a large portion of the area between this and the belt of unequivocally primary character which ranges along the lower falls of our rivers on the east, is to be looked upon as the equivalent of the old red sandstone rocks of Europe. Others who have attempted to sketch the outlines of our principal geological formations, have with even less approach to accuracy, confounded all these strata under the sweeping denomination of primary—and have thus given to the diversified and extensive region whose limits are above described, the distinctive appellation of the primary region of Virginia. Such a view appears to have been adopted by the authors of the map of our state, the brief geological sketch appended to which describes the Blue Ridge as the western boundary of the primary. A more recent writer also, professing to derive his views from an actual examination of the structure of this mountain, has contributed to confirm the prevailing error by proposing as an appropriate name for the Blue Ridge—the title of the Atlantic primary chain. It is deeply

to be regretted that while so little has been done towards a minute exploration of the diversified and complex formations of the region now in question, the writers who have attempted to describe it, and more especially those who have professed to give a scientific exposition of its character, should have observed so little caution in the application of names, and have indulged so much of the spirit of superficial and precipitate generalization. There is no division of the state which presents greater difficulties to the geological inquirer, than the region here referred to, and none which will require for its elucidation more minute and patient investigation. The observations respecting some parts of it, which will be presented in the body of the report, imperfect as they necessarily have been, were directed in part to the determination of some of the difficult problems which this portion of our geology presents—and although insufficient to remove the difficulties in which the subject is involved, will, it is believed, lead to several interesting and important views of a scientific as well as practical nature, while they overthrow the errors which, either through ignorance or inadequate investigation, have hitherto existed. So far from regarding the whole area in question as of a primary character, these observations conclusively demonstrate that the extent of the rocks, to which that title may be unequivocally applied, bears but a small proportion to the whole surface of this division of the state—and while they render it doubtful whether in the Blue Ridge any truly primary rocks occur, they evince the existence in that range, as well as throughout a very extensive district to the east, of sandstones, conglomerates, and other sedimentary deposites, unquestionably referable to a different period of formation.

The gold region, so remarkable for its extent and richness, and the bituminous coal fields of Chesterfield, Goochland, Powhatan and Prince Edward, constitute important divisions of this region of the state, while the slates and soapstones, iron ores, limestones, and other minerals which it includes, are objects of practical as well as scientific interest. To all of these a proper place will be allotted in the body of the report.

(3.)—Our third general division, commencing near the western flank of the Blue Ridge, comprises all the region generally called the Valley, extending westward in the counties of Berkeley, Frederick, Shenandoah and Rockingham, to the base of the several ranges called the Little North mountain, in Augusta and Rockbridge, nearly to the base of the North mountain, and in the counties further south, occupying

an area, which, for the present, does not admit of being accurately defined. Limestone strata of vast extent, hydraulic lime, marble, travertine or deposite marl, slate, iron ore, and in the south, lead ore, are among the valuable materials included in this section of the state. Declining to apply the title of *Transition* to the strata of which this region is composed, because much additional observation is required for the determination of their true geological relations, we must for the present be content with referring them to the oldest of that group of rocks in which the organic remains or fossils have been discovered.

(4.)—The fourth general division to which we shall refer is, at present, even less susceptible than the preceding, of being defined by lines of precise limitation. Nearly the whole of its surface is occupied by chains of mountains, and extremely little has hitherto been done towards exploring its geology. In general, it may be described as comprised between the western limits of the great valley formation and the front ridge of the Alleghany, the Greenbrier and Muddy creek mountains; but with regard to its extent and boundaries further south, nothing definite can be affirmed until it shall have been carefully and systematically explored. Besides the interest in a scientific point of view which attaches to this region, on account of the peculiar structure of its mountains, the stupendous natural sections which it exposes, and the astonishing abundance and variety of the fossil impressions found among its rocks, it claims a high importance from the great value of its materials, economically considered. Its anthracite, pseudo-anthracite, or semi-bituminous and bituminous coals, its limestones, sandstones and grits, and iron ores, and its numerous thermal, chalybeate and sulphuretted springs, constitute collectively an amount of mineral treasures of which few other territories of the same extent are as largely possessed. Without, at present, venturing to apply any precise geological designation to this singularly interesting region, it will be shown to have marked peculiarities which distinguish it from the division previously described.

(5.)—Our fifth and last division, stretching from the eastern limits of the former to the western and south-western boundaries of the state, presents an area of vast extent, and embraces regions abounding in materials of the highest economical utility.

This immense territory, characterised by nearly horizontal strata, gently dipping towards the west refers itself unequivocally to the

group of secondary rocks—and from the numerous and rich beds of bituminous coal which it includes, may with strict propriety be denominated the great secondary bituminous coal region of Virginia. Besides its numerous and widely stretching strata of the abovementioned material, this favoured region possesses the additional treasure of a saline formation of immense extent, towards its western boundary—and if the limits of the region are not improperly assigned, a similar formation, accompanied with gypsum and other valuable minerals in the south-west corner of the state.

(6.)—Pursuing the order in which the several divisions of the state have now been sketched, the *Tertiary marl region* will first claim our attention.

TERTIARY MARL REGION.

The extensive area embraced in this division of the state, though presenting comparatively little diversity in external aspect, includes strata, which, by their fossil contents, unequivocally refer themselves to two distinct geological periods, though they are all without doubt comprised in the general class of tertiary formations. Adopting the names which have been recently applied in Europe to parts of the tertiary series, to which the strata referred to may be regarded as probably equivalent, though without implying any conviction on our part, that such equivalence is in general to be expected in the two continents, we shall indicate by the term *Miocene* the strata which occur in the eastern and greater portion of this region, and from which the ordinary shell marl is procured, while we will apply the name *Eocene* to the deposit of an older date existing beneath and west of the preceding, containing fossils of a different character, and characterised by the prevalence in considerable proportion of the peculiar mineral called *green sand.*

The first of these, or the *Miocene marl district*, comprehends all the area from the seaboard or water boundary of the state on the east, to a line conceived to be drawn through Northbury on the Pamunkey, and Croggin's point on the James river, in a direction nearly meridional, but through what precise points, further observations are necessary to determine.

The other or *Eocene marl district* is comprehended between the imaginary line above described and another line passing from the mouth of Acquia creek, through Wales, at the junction of North and

South Anna rivers, and thence through City Point, and further south in a direction not yet precisely ascertained. Much of the district here defined exhibits Miocene as well as Eocene marl, the former being found either in highlands remote from the rivers, or in the superior parts of the river cliffs overlying the latter. The localities above named were selected as points marking the eastern boundary of this region, because at those places the Eocene marl was observed to disappear below the water line by a gentle dip to the east. Its existence extensively beneath the Miocene district may be looked upon as highly probable, though under what circumstances as to depth and inclination of the beds, we have no positive data to determine.

MIOCENE MARL DISTRICT.

In the most eastern portion of this division of the tertiary, the general level of the surface is but little elevated above tide. The country is a uniform flat, in some places subject to be occasionally overflowed. The rest of the region in question has an elevation above tide, varying from twenty to eighty feet. But few points, however, in the district have a level corresponding to either of these extremes, and by far the larger portion of the surface preserves a height of from forty to fifty feet.

The surface of this more elevated portion, though preserving a general level of remarkable uniformity, is deeply channelled by innumerable ravines. The smaller of these connect themselves with large ones, and these with the wider and deeper excavations forming the beds of the creeks flowing into the neighbouring rivers. The system of ravines connected with one river are separated by a narrow central tract from those connected with the next, and in a general view of the district, these systems present the appearance of mere creeks or inlets subordinate to the great rivers by which this region is broken into peninsulas. The number and extent of the large rivers and the navigable streams of this portion of the state, constitute the most inestimable of its natural advantages. The numerous creeks indenting its peninsulas furnish the cheapest and readiest avenues for a commerce which comes home to the abodes even of its rural inhabitants, while its surface scooped into ravines and its river cliffs washed by the tides, disclose the rich materials which are hereafter to bestow the highest rewards

upon its enterprise, by spreading fertility and wealth to its remotest boundaries.

The superficial stratum of the region we are describing is an argillaceous and ferruginous sand of a yellow and sometimes of a reddish colour, in which are occasionally found at or near the surface, pebbles and small boulders of sandstone, rarely as much as six inches in diameter. The nature of these boulders would indicate that they were most probably derived from the sandstone formation which ranges along the eastern boundary of the primary ridge. In some places this stratum consists of little else than a white silicious sand; in others, the admixture of ochreous clay is so considerable as to furnish a suitable material for the manufacture of bricks.

Beneath this superficial layer, beds of a very argillaceous clay occasionally occur, sometimes of considerable depth and extent, and of a texture to be useful in puddling. Its colour is various, being in some places a dark blue or green, in others a bright red or dingy yellow. Wherever found, its upper boundary is remarkably even and horizontal; but where it rests upon beds of fossil shells, its lower limit conforms to all the irregularities of surface which those beds usually present. Its appearance, in some places, is that of a steep, almost perpendicular wall of smooth surface, and divided by very narrow lines running horizontally. These narrow lines, at a distance of from five inches to a foot asunder, are formed by a more ferruginous and silicious clay. At Bellefield, on the York river, seven miles from Williamsburg, this deposite may be seen overlying the stratum containing shells, in some places having a thickness of from twelve to fifteen feet, and then gradually fining out and passing into a light-coloured and coarser mass. The upper surface is horizontal, and the lines of division above alluded to are perfectly parallel and regular. The lower surface of the clay conforms to that of the shell stratum upon which it rests. In many places these argillaceous beds consist of a yellowish clay, beautifully variegated by streaks of red and blue. In some places there exists a slight impregnation of alum and copperas in these beds of clay. This is particularly the case in some localities on the Rappahannock and the York and Chickahominy rivers. The proportion of these ingredients is, however, not sufficiently great to entitle these strata to attention in an economical point of view, although it is fully sufficient to impart a very ungrateful flavour, and perhaps some useful medicinal properties to the springs and wells of the neighbourhood.

varieties of the soil. Many highly valuable marls extensively in use are of this description.

The very general existence of the lower stratum, above described, forms an interesting and prominent feature in the geology of the Miocene Tertiary districts, as well of eastern Virginia as of Maryland. Throughout all the upper fossiliferous strata, as well as in the argillaceous beds just mentioned, will be found disseminated, greenish black grains of *Silicate of iron and potash*, identical with those already described as existing in the stratum immediately overlying the shells, and having the same form and composition with the granules contained very abundantly in an older formation, both in this country and in Europe. In some beds of the marl or shells, these particles so abound as to give a very decided colour to the whole mass. In specimens from James City and York counties, as much as thirty-five per cent. of the green sand has been found, and occasionally shells are seen filled with this substance almost alone.

The surface of the strata containing shells is usually irregular. Sometimes it rises abruptly, in the form of a hillock, then it is scooped out into depressions of a few feet in depth. These irregularities, however, are apparently of two kinds; the one the original form of the deposite, the other produced by denuding action upon the surface. Thus in many places the same stratum may be remarked, rising with more or less abruptness, then again descending, and perhaps preserving a nearly horizontal line for some distance, marked at its upper surface by a clear and unbroken outline, and presenting no indication of violent abrasion from above. In other places, and this is a very frequent occurrence, deep and irregular furrows and cavities are seen, such as would naturally arise from the action of the currents and eddies of a large mass of water in rapid movement. Whether from this cause, or from the gradual dissolving action of percolating water, *sinks* exist in this region in many places, though they are by no means as numerous or extensive as in the limestone districts.

Having thus given an account of the nature and arrangement of the strata overlying the shells, as well as those in which they are embedded, we will now describe the general condition and disposition in which the shells occur.

CONDITION OF THE SHELLS IN THE TERTIARY DEPOSITES.

In general the state of the shells, and their arrangement in the earth, are such as to indicate their tranquil deposition at the spots in which they are found. Thus the corresponding valves are very often found together and closely shut. Many of the smaller shells, such as Arca centenaria, Arca incile, Nuculæ, Venericardia alticosta, and Chama congregata, which are most usually found thus, are often either entirely empty, or contain a small quantity of clay that is quite impalpable, indicating plainly that they have been exposed to no violence, and that only such solid matter as could pass between the edges of the closed valves had obtained access to the interior. Whenever such shells, however, have been previously drilled, as is very frequently the case, even with the largest and thickest shells, the interior is found entirely filled with sand, clay, green sand, and small fragments of shell. In most cases the larger species of shells, even when their valves appear to be in accurate juxtaposition, is thus filled, and in this case it cannot be supposed that the contained matter has entered through the holes thus drilled, since in many instances shells of considerable magnitude are found imprisoned within. Such shells, no doubt, after the death of the animal, remained open, or at least partially so, and received the sand, clay and other materials which they contain, by the gentle action of the waves. The ligament at the hinge in the mean time would decay, until at length, yielding to the pressure of the accumulating matter above the shell, in favourable circumstances, would collapse into its natural closed condition.

The very common occurrence of the valves in juxtaposition, is a striking proof, that during or subsequent to their deposition, they have not been exposed to violent agencies. This becomes even more remarkable in the case of such shells as the Panopea reflexa, which almost in every instance is found with the valves properly united. The connexion between the two valves in this shell is the slightest imaginable, after the destruction of the natural organic bond, and an inconsiderable force would have sufficed to separate and break the valves.

The admirable preservation of the shells in many cases is also an interesting fact, and affords another evidence of the absence of all violent agencies at this period. The most fragile species of Natica, delicate Tellinæ, Mactra Tellinoides, the shell and processes

of the Crepidula, the minute and sharp angles of the Fusus Tetricus, the thin and hollow Fissurella—are found in perfect preservation in many places. The state of the shells seems to depend chiefly upon the mechanical texture and chemical character of the materials with which they are mixed, and of which the overlying stratum is composed. In the moist blue clay, the shells are generally found in a very soft condition. In a highly ferruginous clayey bed they are found either partially or entirely dissolved, and beautiful casts remain in their stead.

In many places entire banks occur, composed of *casts* of Chama and other shells, sometimes separate, sometimes cemented together so as to form a species of rock. These appearances occur chiefly near the surface, and when the soil is porous and ferruginous. The casts thus formed, often consist chiefly of carbonate of lime, and in many specimens as much as *eighty per cent.* of this substance is found. Casts of this kind belong mostly to the smaller shells, and by far the most common are of the Chama congregata. These, as already stated, are often found nearly or quite empty, and we may, therefore, conceive, that as the matter of the shell in an extensive bank of Chamas is gradually dissolved, the water charged with carbonate of lime enters the cavities, and slowly deposites the carbonate mixed with fine particles of clay and sand. Thus by degrees the cavities are filled. In the mean time the shell disappears, frequently leaving on the surface of the cast a chalky covering, like the decomposed inner film of shelly matter. In support of this explanation it may be added, that in many casts beautiful crystals of carbonate of lime are found, forming a portion of the cast, and having the appearance of Dog-tooth Spar. In some cases the shelly matter appears to have been dissolved, and its place supplied by the crystallized carbonate, encrusting the earth formerly contained within the shell. Sometimes, too, a thin film of oxide of iron surrounds the cast, showing very distinctly all the markings of the inner surface of the shell. In many localities, presenting a series of beds differing in composition, the shells will be found perfect in some of them, while in others immediately above or below, only casts remain. Thus at the College mill, about one mile from Williamsburg, the upper fossiliferous layer is a yellow silicious sand, containing perfect shells. Below this is a brown ferruginous clay, filled with the most beautiful casts of Chama, Pectunculus, Turritella, &c. The shelly matter has entirely disappeared, and the

casts lie loosely in the cavities produced by the removal of the shells, entirely distinct from each other, and covered by a film of oxide of iron. The layer beneath, consisting of bluish green silicious clay, is full of well preserved Pectens, Pernas, and a variety of other shells.

In general, the various species of shells are found associated in colonies or groups, but, as in the case of banks of recent shells, these colonies contain many scattered specimens, differing from the general contents of the group. The two species of Chama, the C. congregata and C. corticosa, which are found in almost every deposite of shells in this region, in many cases form extensive beds, with a very small admixture of other genera. The best agricultural marl, of a purely calcareous nature, which is used in lower Virginia, is derived from these beds of Chama, the friable texture of the shell upon exposure to the air, rendering this species of marl more easy of application to land, and more prompt in its ameliorating effects. Crassatellæ often form an extensive deposite, and the large Pectens occur in continuous layers of considerable depth and extent. The different species of Arca, Artemis Crepidula, &c. present a similar arrangement. Even those shells which are of comparatively rare occurrence, are usually found in little groups. Thus the Isocardia fraterna is found, to the extent of a dozen or twenty, closely packed together. This gregarious assemblage of shells of the same species is what would naturally be anticipated in the absence of violent agencies during or after their deposition, and furnishes another very striking proof of the comparatively tranquil condition of the sea or estuary in which they were allowed to accumulate.

DISPOSITION OF THE FOSSILS.

In nearly all the vertical sections of the deposite we are now describing, a series of beds or strata may be observed, each distinguished by the predominance of one or more species, and the order of superposition of these beds frequently continues without interruption for some distance. It does not appear, however, that in localities remote from each other, the arrangement of the shells is always alike, although in many instances there appears to be a striking correspondence. In a majority of cases in the neighbourhood of Williamsburg, the upper layer is composed principally of Chama congregata. In many localities also, the large Pectens

mingled with Ostrea Virginica occupy the highest place. But generally, the same shell re-appears as a predominant constituent of one or more of the subjacent beds; and such is the diversity of arrangement, even in places but a few miles distant, that it is obvious that no general order of succession exists. Thus, in a range of three miles we find Perna maxillata in some localities in the lowest stratum of dark blue argillaceous sand; in others, forming an upper, or even the highest layer of the series. At Waller's mill, three miles from Williamsburg, this fossil overlies the other shells; whereas at the College mill, as already stated, it forms a part of the lowest visible stratum.

With the view of conveying more precise ideas of the disposition of the fossils in this region, we annex the following details in relation to some of the more important localities, which have been minutely examined.

King's mill, one of the most interesting fossil localities in the neighbourhood of Williamsburg, is situated on the north bank of James river, about twenty-five miles from its mouth. The cliff in which the shells appear is abrupt, and has a height varying from twenty to forty-five feet above the water. The strata of shells extend along the river with slight interruptions, when the cliff sinks nearly to the level of the water, for a distance of between two and three miles, and they are found in a somewhat similar order of superposition for some distance inland. Their general direction is horizontal, but the outline of any one stratum is frequently very irregular, the surface rising and falling with a steep inclination. This irregular outline is particularly remarkable with the beds of Chama, which are very thick at some points, and then fine out rapidly and again expand.

This deposite of shells is covered to the depth of from four to six feet by a brownish yellow sand, intermixed with stripes of clay. Beneath this is a thin layer of about one foot, of very argillaceous and ferruginous clay of a red colour. This rests upon a few inches thickness of gravel, consisting of water-worn quartz, rarely larger than a pea. Beneath this is a layer, from one to two feet thick, consisting of yellow sand, containing a great deal of the green or chloritic sand, arranged in narrow stripes. Next follows a layer of the same sand, containing principally Chama and Venus deformis. This is from two to three feet in thickness. Immediately below is a stratum consisting almost exclusively of Chama, with a few Arca

centenaria, &c. This stratum, varying from three to four feet in thickness, is a mass of compacted shells, with but little earthy matter intervening. The earthy matter contains a very large proportion of the chloritic sand. The next stratum is composed chiefly of large Pectens, and has a thickness of from one to two feet. Below this is another dense stratum of Chama, together with Arca centenaria, Panopea reflexa, &c., and also very rich in the green sand. Thickness, from four to six feet. Then follows a second layer containing Pectens with Ostrea compressirostra, one foot in thickness. A third stratum in which Chama predominates, follows next, in thickness from two to three feet, and at the base of the cliff is a layer containing Pectens, Ostrea compressirostra, &c. from four to five feet in thickness.

Thus through a height of more than twenty feet in some places, the cliff consists principally of shells, of which there are a great many species, besides those mentioned as predominating in the several beds. On the extensive contiguous estates of King's mill and Littletown, these shells are largely used as a manure: and for this purpose the first and second beds of Chama are preferred on account of the immense amount of calcareous matter, and the large proportion of green sand which they contain. Judging from the occasional appearance of bluish green clay on the line of the beach, and in some places immediately at the base of the cliff just described, it is highly probable that a continuous stratum of this substance lies beneath the other beds throughout the whole extent observed. A horizontal bed of yellowish clay extends for some distance along a lower portion of the cliff, in which there are no fossils; running within a few feet of its upper edge, and beneath this bed, and parallel to it, is a thin layer of the iron ore formerly described. At the foot of this cliff appears the underlying stratum of clay.

DESCRIPTION OF THE CLIFFS AT YORKTOWN ON YORK RIVER.

The elevation, abrupt form, and peculiar construction of the cliffs at this point, and for some distance, both above and below, render it an interesting spot to the geologist. A dry and ample beach, uninterrupted by creeks or inlets for several miles, affords a ready access to the banks, while the river's edge, strewed with fossils which have fallen from the cliff, exposes a considerable variety of

interesting specimens. Immediately at York, the river is only three-eighths of a mile in width, but both above and below it expands to a breadth six or seven times as great.

At Wormley's creek, about two miles below the town, the cliff about to be described begins; but from this point, down to the extremity of the peninsula, the banks are uniformly flat and low. The cliff here consists at bottom of a bluish sandy clay, containing immense numbers of Turritella alticosta, Cytherea sayana, and many small Univalves, over which lies a layer of brownish yellow sand, with very few shells, and those chiefly Nucula limatula, and a few other species. To this succeeds a stratum composed almost entirely of Crepidula costata, so closely packed together, as to leave little space for sand or other earthy matter. The whole is covered to a variable depth by a stratum of coarse sand of various strong tints, and evidently highly ferruginous. The elevation of the cliff increases, and the nature of its contents gradually changes in approaching York. The lower stratum disappears entirely after continuing for something less than half a mile, previous to which, however, its fossil contents are changed; the layer of the Turritellæ being replaced by Crepidula closely packed together. Crepidula still runs on horizontally above, and the intermediate stratum is now densely filled with Pectens, Venus deformis, Ostrea, and a great variety of small shells frequently connected together, so as to form hard masses of considerable size. Still higher up the river the deposite assumes the character of successive layers composed of comminuted shells, connected together so as to form a porous rock. These fragments are generally so small and so much rubbed and water-worn, as to render it impossible to ascertain the species of shells of which they once were portions. Many small shells, and occasionally large ones, particularly Pectens, are found mingled with the other constituents of the rocks; and in some places thin layers of shells, such as Venus and Crepidula, intervene between the adjacent strata. The height of this fragmentary rock amounts in some places to forty feet. In most places it has a highly ferruginous aspect, though this is not invariably the case. Frequently shells of considerable size, such as Lucina anodonta, are seen coated with, or entirely changed into, crystalline carbonate of lime, firmly cemented in the mass. The texture of the rock is various, at some points admitting of being readily excavated by the pick and spade, so as to form caves which have been occasionally used by the in-

habitants; in other places exhibiting a hard and semi-crystalline structure, and having the compactness of some forms of secondary limestone. The lower portion of the cliff, having less cohesion than the rest, has been scooped out by the action of water, so as to give it occasionally an impending attitude.

Above the town, the stratum of fragmentary rock becomes much thinner, being now reduced to about ten or twelve feet. A stratum of yellowish argillaceous clay, abounding in Artemis acetabulum, Mactras, and other large shells, lies immediately beneath the rock; and lower still, appears the stratum of bluish clay, filled with Nucula Limatula, several species of Fusus, and various other fossils.

A narrow layer of *iron ore* extends along the cliff, with occasional interruptions, at a small distance above the fossiliferous strata.

This fragmentary rock continues in a narrow band, with some interruptions, for about a mile and a half above York. Beyond this point it is met with chiefly in detached masses. Extensive beds of shells, similar to those which appear at York, come to view in the vicinity of Bellefield, and line the shore for a distance of about three miles. These beds rest on the usual stratum of sandy clay, and are in some places, as already described, covered by a stratum of the same substance. At a still remoter point, about six miles above York, on Jones' plantation, a porous rocky mass occurs, overlying the stratum of shells in a thin and interrupted layer. Though very similar in appearance to the fragmentary mass before described, and evidently at one time composed of portions of shells, it is almost devoid of any trace of carbonate of lime. It appears to consist of silex, slightly tinged with oxide of iron; approaching in its porous character and harsh gritty texture, to the nature of the burr stone of France. Associated with this, is a more compact rock, containing some carbonate of lime, with much silex, and exhibiting very perfect casts and impressions of Pectens, Cardium, &c. Over these strata is the usual layer of ironstone, and the general aspect of the upper beds is somewhat ferruginous.

It is interesting to remark, that with some interruptions, a fragmentary deposite, similar to that observed at York, extends to the lower extremity of the peninsula. At Pocosin, a flat swampy country, which is often inundated by the tides, this deposite is uniformly met with by digging a few feet below the surface. Pectunculus, Pecten, Ostrea, as well as numerous small shells, occur

mingled with it, as at York; the fragments, however, are not cemented together but form a loose friable mass. A rock, consisting of cemented fragments of shells, occurs also at various other points on the eastern portion of the Miocene district; and a fragmentary deposite, like that above described, is found near the extremity of all the peninsulas formed by our great rivers.

A very interesting feature in the structure of the cliff at York remains to be described. Though the general direction of the fossil beds is nearly horizontal, several of the strata of rock are composed of transverse layers parallel to each other, generally dipping towards the north, and making an angle of fifteen or twenty degrees with the horizon. The course of these laminæ sometimes differs in adjoining strata, and in some places the obliquity diminishes gradually until the laminæ become horizontal; thus presenting a remarkable resemblance to the appearances described by Lyell and others, as existing in the Crag of England. The phenomenon here described, viewed in connexion with the fragmentary structure of the rock, and the general distribution of broken shells over the lower extremity of the peninsula, would seem to indicate the former agency in this district of coast currents and an ocean surf. The beds of shelly matter comminuted by these means, and subsequently elevated above the level of the tide, would be gradually cemented into a rocky mass by the crystallization between the particles of such portions of the calcareous matter, as the rain when just fallen was capable of dissolving. The solvent power of rain, being chiefly due to a portion of carbonic acid with which it becomes united in its descent through the air, would be lost, as the liquid percolated through the shelly strata, and thus the calcareous matter which it had seized, would be gradually deposited in the crystalline form.

Besides shells and Zoophytes, the bones of cetaceous animals and the teeth of sharks, are of very frequent occurrence in the fossiliferous beds, but no remains of *fresh water or land animals* have as yet been discovered. The total number of species of shells from these points which have yet been identified, is about ninety-six, to which may now be added several new species recently discovered, and described in a joint paper by Professor H. D. Rogers and myself.

The structure of the interesting portion of the state lying on the eastern side of the Chesapeake is, so far as hitherto explored, extremely simple; but as yet only the surface strata have been

examined, and it is far from being improbable, that at no very considerable depth beyond that reached by the ordinary wells of the country, deposites calculated to prove of much economical value, might be attained. Beneath the superficial sands and sandy clays of the country, a bed of clay of a tenacious character is first reached, frequently impregnated with salt, and communicating to the water obtained from it more or less of a brackish flavour. Beneath this a more arenaceous bed occurs, beyond which, as far as I can learn, no digging has been carried. From this more sandy stratum, water of a purer quality is procured. Hitherto no beds of marl or fossil shells have been found anywhere in this region. Yet there is reason for the opinion, that such deposites would be met with by boring to some depth, and possibly near enough to the surface to prove available in the agriculture of the country.

The water of the Miocene marl district, whether of wells or springs, presents nearly as great variety as the mineral beds from which it issues. In the more eastern parts of the region, it generally contains a notable impregnation of common salt, and in neighbourhoods where shell marl abounds, a marked proportion of calcareous matter. The copiousness and transparency of springs of the latter description, as well as the carbonate of lime which they hold dissolved, give them a character nearly allied to that of the *limestone springs* of other regions, while the common salt which they almost invariably contain, and with which they are sometimes strongly imbued, constitutes an important feature of distinction. The beds of ferruginous clay and sand in many cases, impress a slight chalybeate character upon the water, and occasionally impart to it so large an impregnation of iron as to render it of decidedly medicinal utility.

Owing to the calcareous matter, and occasionally other substances which it holds in solution, nearly all the water of this region possesses the character of *hardness*. By *boiling*, this evil is entirely remedied;—the carbonate of lime is precipitated, first rendering the liquid cloudy, and subsequently collecting on the sides and bottom of the vessel in the form of a thin incrustation. In such of the arts as require a water free from this peculiarity, the marl water should be boiled previous to use; or, in lieu of this, though by no means an effectual substitute, it should be exposed for some time to the sun in open reservoirs. The carb. acid which is the chief solvent of the calcareous matter, being expelled by heat, suffers the latter to separate

from the liquid, and thus the cause of the hardness of the water is in a great degree removed. It is obvious from these facts, that the water obtained from strata of gravel, sand or pure clay, will in general be purest and most suitable for employment in the arts. As an example of the kind of impregnation usual in the water of this district, I subjoin the results of an analysis of the contents of a spring in James City county, near Williamsburg. In 400 cubic inches of this water, the aggregate of solid matter was found to be 104.49 grs. consisting of the following substances, viz:

Muriate of soda,	49.84
Muriate of lime,	15.08
Carbonate of lime,	26.73
Sulphate of lime,	6.24
Silica and alumina,	4.00
Sulphate of soda,	0.25
Ammonia,	*a trace.*
Organic matter,	1.00
Loss,	1.75
	104.49

The large proportion of Muri. soda shown to be present in the above instance, is an interesting fact, particularly when taken in connexion with the locality whence the water was procured. For, it cannot be considered probable that this ingredient could be derived from the neighbouring rivers or the bay, as this would imply an extent of filtration in a horizontal and upward direction, which it would be unphilosophical to admit. It is rather, as I conceive, to be looked upon as referable to the former impregnation of saline matter derived from the waters of the ocean, beneath which nearly all the strata of this region were originally deposited.

NATURE AND VARIETIES OF THE MIOCENE SHELL MARL.

In the general description of the district of which we are now treating, a detailed account has been given of the arrangement of the beds of fossils as they occur in nearly all the localities which have been examined, accompanied by an enumeration of the principal shells, an account of the materials in which they are embedded, and with which they are associated in contiguous strata. We are next to consider the materials of these beds in relation to their agricultural importance, and to exhibit the relative value of the marl of

different localities as illustrated by chemical examination. A large proportion of the matter of all shells consists of *carbonate of lime.* Hence they are nearly identical in composition with limestone, chalk and marble. To this ingredient, in whatever form it may be applied to the soil, general experience has ascribed a very high degree of fertilizing power, and hence, in the application of all the varieties of calcareous marl, we are guided chiefly by the proportion of the carbonate which they contain, as determined by chemical analysis. It should not, however, be inferred, that the various mixtures of earths and other substances with which the calcareous matter is usually associated, are devoid of useful action when applied to land. The experience of agriculturists is certainly inconsistent with such an opinion, though it has most clearly evinced the powerful efficacy of calcareous manures. The invaluable publications of the editor of the Farmer's Register by directing the attention of farmers to the employment of the shell marl with which nature has supplied them in such rich abundance, have led so extensively to the application of this manure, and have produced so general a conviction of its fertilizing effects as to render it unnecessary in this place to introduce either facts or arguments in its favour. To the valuable practical suggestions of this gentleman, contained in the " calcareous manures" and other publications, we are indebted for much of the amelioration which has taken place in the agriculture of eastern Virginia, and I therefore cannot do better, in alluding to this branch of my subject, than to recommend these works to the earnest perusal of all who are interested in advancing the prosperity of that portion of the state.

But although the richness of the marl is mainly dependent on the *proportion* of its calcareous contents, it is also largely influenced by the *nature* and *condition* of the shells of which it is composed. It is well known that the recent oyster shell, especially in its unbroken state, is far less immediate and powerful in its action upon land than the friable and pulverulent shells, of which many of the most valuable marl beds are principally made up. Yet in the composition of the recent oyster shell, the amount of calcareous ingredient is nearly as great as in the richest marl beds which we have examined. According to an analysis which I made some years ago, 100 grains of this material were found to contain:

Carbonate of lime,	95.18 grs.
Phosphate of lime,	1.88
Silex (probably accidental,)	0.40
Water,	1.62
Insoluble animal matter,	0.45
Loss, &c.	0.45
	100.00

[*Vide Farmer's Register, Vol.* 1, *and Silliman's Journal.*

These remarks being also applicable to some species of fossil shells, it becomes necessary to a judicious selection of the marl, to give some attention to the different nature of the shells contained in the several varieties of marls offered to our choice.

KINDS OF SHELLS WHICH ARE LEAST LIKELY TO BE USEFUL.

The Fossil oyster and Scallop shells, (Ostrea Virginica and Pecten,) of which many marl beds are almost exclusively composed, are generally found in a nearly unaltered state. Comparing the composition of these shells, as ascertained by my analysis, with that of the recent shells, the *animal* matter which, though small in quantity, seems to act powerfully as a cement for the other materials, was found to have been retained in almost undiminished proportion; and thus these shells are scarcely better fitted for the soil, than recent ones of the same species. It is to the animal matter retained by the fossil scallops that we are to ascribe the dark colour which they assume when burnt for lime. Whatever might be the usefulness of this ingredient if mingled with the soil, it here operates to impair the value of the shell as calcareous manure by the insoluble character it imparts to the materials it holds together. Next in tardiness of disintegration, and in consequent inefficacy as a manure, may be enumerated the large clam, (Venus mercenaria,) and an oblong smooth flat shell, (Crassatella.) These, however, have evidently undergone a change, which prepares them for yielding, more readily than the former, to the agencies of the seasons. Most of the other species, though entire when first found, soon fall to pieces and spread their fertilizing fragments through the soil. There is, however, even among them some room for choice—and this leads us to consider the

KINDS OF SHELLS WHICH ARE MOST SUITED FOR THE PURPOSE OF MARLING.

The Chama, formerly mentioned as occurring in extensive beds in some portions of the Miocene, and existing in considerable proportion in nearly all the fossil strata, forms the principal component of some of the most productive marls. This is a small two-valved shell of rugged exterior, which readily breaks to pieces in the ground, and is spread evenly over the land with great facility. Another shell, (Serpula,) of which there are numerous rich beds in Surry county, possesses these advantages in a still higher degree. From its fragile texture, and irregular tubular structure, it is quickly mingled with the soil in a minutely subdivided state, and as like the Chama, it frequently occupies the marl beds to the exclusion of other fossils, it furnishes a marl of a very superior description. As a general rule, the small shells are most likely to prove efficacious, as well from the fact that, where they occur, the proportion of carbonate of lime and green sand is usually great, as because they are most easily reduced to the condition in which they become available in the land.

Of the Pulverulent white marl.—In many situations the marl presents an appearance not very unlike that of an impure chalk. The mass of the stratum is chiefly made up of a white or yellowish friable material, intermixed with fragments of the harder species of shells. In such cases the shells are rarely found entire, and the condition of the fragments is usually such as to render it difficult to recognise the species of fossil to which they belonged. Many extensive beds of marl of this description have been opened in the counties of Middlesex, New Kent, James City, York and Gloucester, all of them largely abounding in calcareous matter. Even as much as 97 per cent. of this substance was found in a specimen from one of these localities; and it will appear from the table of calcareous marls hereafter to be given, that in general the proportion exceeds 80 in the 100. Occasionally, however, a mixture occurs in which the calcareous matter is blended with a large proportion of white clay and sand, presenting in the mass an aspect so nearly resembling the former, that without chemical analysis it would be difficult to distinguish between them.

Of the Blue marl.—In our general description of the arrangement of the fossiliferous strata, mention has been made of the bluish green or clayey marl which occurs low down in the ravines and near the

amongst farmers as the blue marl. From the soft condition of the shelly matter which it contains, and the predominance of clay in its composition, this has been found peculiarly serviceable when applied to the more arenaceous varieties of soil. In the quantity of calcareous matter which it contains, it is usually inferior to the beds of a white or brown colour, which in many places rest above it, though it is not to be inferred that in many instances it may not prove equally advantageous to the land. The colouring matter of the clay appears in part to consist of a carbonaceous matter, derived probably from the organic materials originally associated with the shells, and often in part of a minutely divided greensand, either of which ingredients might be expected to aid the calcareous and clayey matter in benefiting the soil.

Of the hard Ferruginous Marl.—In some localities the beds consist of shells more or less broken, intermixed with a brown ferruginous sandy clay, and often cemented with these materials into masses which are broken with some difficulty. These, although rich in calcareous matter, must obviously, from their mechanical texture, prove less valuable than either of the former. To this class, also, may be referred the shell rock, and fragmentary masses approaching to limestone, which occur in various places.

From the large per centage of carbonate of lime, which these contain, there can be no doubt that, by burning, they might be converted into a highly valuable lime. A specimen from the cliff at York, yielded eighty-seven per cent. of calcareous carbonate, as large a proportion as most of the valley limestone have been found to contain: computing the quantity of caustic lime, corresponding to this, we find that one hundred pounds of the shell rock would yield 48.7 pounds of strong lime. It is, therefore, well worthy of consideration, whether the conversion of this material into lime, might not be an object of profitable enterprise. In the neighbourhood of York and other places, where it occurs, rock of sufficient hardness might be obtained in great abundance and at comparatively little cost; and the cheapness of fuel would render the operation of burning, one of moderate expense. That much of this rock, when exposed to intense heat, would fall to pieces, and thus injure the value of the product for distant use, is undoubtedly true. But there is also much of it found in bands throughout the cliff, which has almost as great solidity and permanency in the fire, as a secondary limestone, and from this, a lime of superior character might unquestionably be

produced. Owing to the great abundance of shell marl in these places, and the general resemblance of this material to the constituents of a marl bank, its probable utility in this point of view, appears hitherto to have been overlooked. But regarding it in its true light, as a *tertiary limestone*, we see no reason why it should not become a source of profitable manufacture in its immediate vicinity.

OF THE GREENSAND, SULPHATE OF IRON, SULPHUR, AND OTHER MATTERS ASSOCIATED WITH THE MARL BEDS.

Greensand.—As already intimated, this substance is frequently found disseminated in the marl, and also in the overlying stratum of clay or sand. From the remarkable effects of comparatively small quantities of this material when applied to land, there can be no doubt that many of the marls of lower Virginia owe some of their value to its presence. Supposing only as much as ten per cent. of this substance in a marl, and this is far below the amount which I have ascertained to exist in many localities, one hundred loads of marl would correspond to ten of the greensand, an amount which in New Jersey has often been found productive of striking benefit. Several of the most efficient marls which I have examined, were more remarkable for the large proportion of this substance contained in them than for their richness in calcareous matter. In many marl pits which I have visited, the impressions of the pick and spade were streaked with green marks, which upon inspection were found to result from the bruised granules of this matter. In such cases, there can be no doubt of the existence in the marl of an amount of greensand capable of affording material aid to the growing vegetable. In the layer immediately above the marl, also, it sometimes exists in considerable quantity—and hence instead of rejecting this overlying mass, in many cases it would be decidedly better to carry it out upon the land along with the calcareous matter. The experience of many farmers has already shown the propriety of this plan, and some even entertain the opinion that this upper layer, where the greensand abounds, is quite as beneficial as the marl itself. Further observations respecting the greensand will be given in treating of the Eocene marls, of which it constitutes a very important ingredient.

Sulphate of Iron and Sulphur.—In some parts of the Miocene district, there occur beds of clay more or less sandy, and usually of a dark colour, containing these substances in a minute but still ap-

preciable quantity. Such matter, there is reason to believe, would not in general prove directly beneficial to the soil. The former has been thought positively detrimental to vegetation, and certainly when applied in considerable quantity, this is its effect. What agency it might exert in a more diluted state, and mingled with other matter, we are without the means of determining. Probably under such circumstances it might operate as a stimulant, and thus contribute to the growth. The same doubts are also applicable to the other substance above named. Yet in some well authenticated cases, the action of these *copperas and sulphur* clays has been found strikingly beneficial. In these instances, however, it would seem that much if not all the benefit was produced by the effectual protection which even minute quantities of these substances, especially the latter, afford against the attacks of insects. In a cotton field in which all the alternate rows were lightly sprinkled with earth of this description, the plants so treated grew up vigorous and healthy, while the others became sickly and were nearly devoured by insects. Much careful observation is required to determine the kind and mode of influence which these substances exert, and it would be premature, in our present ignorance of the matter, to assert any convictions on the subject. The presence of the former of these ingredients, if not recognised by the copperas flavour, will be readily discovered by steeping the earth in water, decanting the clear liquid, boiling it down to a small volume, and then adding tincture of galls or prussiate of potash. A black or brown colour with the former, or a blue one with the latter, would indicate its presence. The experiment, however, should be made in a glass or china vessel. The sulphur becomes manifest to the smell when the clay is heated, and even at ordinary temperatures its peculiar odour may often be perceived.

The following table exhibits the per centage of carbonate of lime in a number of the Miocene marls which I have examined. The analysis were made with the "apparatus for analysing calcareous marls and other carbonates," described in The Farmer's Register and Journal of Science. No attempt was made to ascertain the proportions of sand, clay or greensand, because the trouble of the analysis would have been increased more than ten fold, and probably no *useful* result could have been attained. In each experiment the appearance and character of the undissolved matter was noted, and thus a general estimate formed of the other ingredients of the speci-

men. These notes are contained in the fourth column, the first giving the localities, the second the aspect, and the third the quantity of calcareous matter.

TABLE, *exhibiting the per cent. of Carbonate of Lime in Miocene Marls.*

GLOUCESTER.			
Walter Jones, . . .	White sandy marl, with fragments of Perna, . .	37.1	The residuary matter chiefly silex—No greensand.
Walter Jones, . . .	White clayey marl, . .	61.5	The residuary matter chiefly clay, with a little g. sand.
T. W. Fauntleroy, . .	White pulverulent, . .	60.0	Chiefly clay—No g. sand.
T. W. Fauntleroy—several feet below surface, . . .	Fine chalky—few traces of shells, ...	96.8	No g. sand.
Do.—from same bed near the surface, ...	More arenaceous, . .	61.8	Sand.
Dr. Taliaferro—from gray low grounds, ...	. . . . . .	40.0	
Do.—black low grounds, .	. . . . . .	68.1	
Do.—highlands, upper stratum,	. . . . . .	57.2	
Do.—highlands, lower level,	. . . . . .	35.9	A little g. sand.
ISLE OF WIGHT.			
Burwell's bay, . . .	Blue marl, . . .	62.0	A little g. s.—chiefly clay.
Ditto, ...	Yellow marl, . . :	55.2	Sand, clay, and a considerable proportion of Peroxide of iron.
Joel Holleman, . . .	White, with small shells, .	80.2	A little g. sand.
JAMES CITY.			
The Grove—Burwell's, .	Reddish gray, with fragments of shells and numerous specks of g. sand, . .	60.2	Sand, clay, and large proportion of g. sand.
Do.—from a lower stratum, .	Similar appearance—specks more numerous, . .	54.7	Do. do.—still more g. sand.
King's mill cliff, . . .	Similar aspect, . . .	62.0	Do. do.—much g. sand.
Judge Semple's farm, two miles below Williamsburg, .	Similar aspect, . . .	79.0	Do. do. do.
Dickie Galt's, near Williamsburg hospital, . . .	Pulverulent and white, .	79.0	No g. sand.
Dr. Semple, thirteen miles from Williamsburg, . . .	Yellowish pulverulent, .	84.3	Sand and clay.
Do. do.—another stratum,	Grayish yellow, . .	54.5	Do. do.—and some g. sand.
Dr. Peachy's, near Jamestown,	White pulverulent, . .	72.0	Chiefly clay.
Mr. Wynn's, near York, .	Do. do. . .	72.7	Clay, and a little g. sand.
Mr. Wade's, . . .	Do. do. . .	69.1	Do. do.
LANCASTER.			
Carratomen—J. Cabell, Esq.—1st bed, ...	Grayish yellow—silicious clay filled with hollow casts of Astarte Undulata, .	48.8	Clay, sand, and ox. iron—No g. sand.
Do. do.—2d bed, . .	Fragments of shells, but no casts, ...	54.6	Do.
Do. do.—3d bed, . .	Do. do. . .	57.4	Do.
Do. do.—4th bed, . .	Do. do. . .	52 7	Do.
Do. do.—5th bed, . .	Do. do. . .	38.4	Do.

MIDDLESEX.			
Mr. Jesse's, near Urbanna—No. 1, ...	White pulverulent, . .	92.3	Chiefly clay.
Do.—No. 2, ...	Sandy and greenish blue, .	33.0	Much g. sand.
Dr. R. Christian, near Urbanna,	Chalky—small fragments of shells, ...	59.5	Sand and clay.
Mrs. Thruston's, 8 miles from Urbanna, ...	White and pulverulent, .	95.4	
NEW KENT.			
Mr. B. Crump, five miles below court-house, . . .	White pulverulent, . .	93.6	
Mr. Ro. Christian's, . .	Do. do. . .	76.1	
Mr. J. Marshall, . . .	Do. do. . .	85.0	
PRINCE GEORGE.			
Mr. Wm. Harrison, . .	Do. do. . .	72.7	
SURRY.			
Mr. C. Jones, . . .	Grayish, ...	28.3	Sand and clay, and much g. sand.
Mr. C. Jones—lower stratum,	Grayish yellow, . .	43.2	Sand, clay, ox. iron, and much g. sand.
Do.—upper stratum, . .	Abounding in Chama, .	62.7	Do.—much g. sand.
Capt. Smith, court-house, .	Bank made up of Chama and Serpula, . . .	72.9	Much g. sand.
Bacon's Castle, . . .	White pulverulent, . .	97.7	No g. sand.
Mr. D. Stith, court-house, .	White sand, with fragments of Perna, . . .	35	Sand—no g. sand.
Union Hall, . . .	Very argillaceous, . .	29.8	No g. sand.
YORK.			
Mr. R. Garrett's, three miles below York, . . .	White pulverulent, . .	90.2	
Belle farm—Major T. Griffin,	Reddish yellow—fragments of shells, ...	79.2	Clay and ox. iron.
York cliff, ...	Rocky and subcrystalline,	87.3	Do. do.

EOCENE MARL DISTRICT.

As already indicated, the extent and boundaries of this interesting portion of eastern Virginia are as yet in a great degree matters of conjecture. The discovery of an Eocene deposite in the state first announced by me about eighteen months ago, in a communication to the Farmer's Register, has been followed up by a minute personal examination of some parts of the district in which it occurs, more especially on the James river and Pamunkey. Its existence on the Rappahannock and Potomac has also been ascertained, and specimens have been obtained from a number of intermediate points. With regard to the region South of the James river, though facts have been procured which show conclusively that the deposite continues to the southern boundaries of the state, time has not admitted of such an investigation as would be necessary in defining its extent. A regularly continuing line of observations on the

Pamunkey river, commencing below the point at which the deposite appears above the water's edge, and extending up the river to the junction of the North and South Anna, where it terminates, has served to develope the arrangement and composition of the strata, and to determine the width of this portion of the formation. An inspection of the most important Eocene localities on the James river has also contributed many interesting and valuable facts, while on the Rappahannock and Potomac, its western limits have been determined with as much accuracy as could be attained by transient observations directed only to a few localities.

Wherever observed, the arrangement of the beds of the Eocene and the minerals and fossils contained in them, have been found strikingly alike, and hence the description of any transverse line of the formation may be regarded as conveying a just representation of its character throughout. At the same time, however, it is by no means to be assumed, that in all localities the same arrangement or composition of the strata must necessarily exist; for within a short distance in observations already made, considerable diversities have been observed to exist. But there can be little doubt that the general order of the strata already remarked, as well as the character of the fossils which they contain, will present much uniformity whenever the formation may be discovered within the limits of the state.

The existence of Miocene strata over the Eocene, has been referred to under a former head, and some account of this more recent overlying deposite within the district of which we are now treating, may, with propriety, be prefixed to the description of the Eocene itself.

OF THE MIOCENE WHICH OVERLIES THE EOCENE.

Westward of the limits of the Miocene previously defined, the general level of the country continues gradually to rise. A surface more generally undulating, and strewed with water-worn fragments of stone, sometimes of considerable size, marks our approach to the region of hills and rocks, whence these memorials of the destructive forces of a former period have been derived. The superficial strata in the western portion of this district is generally a coarse sand or gravel, often containing large masses of rounded sandstone and other rocks, of which the parent strata are gene-

rally to be found at no remote distance to the northwest. An inspection of these pebbles is sufficient to show, that in many, if not nearly all cases, they are derived from the grits and sandstones with which the bituminous coal of eastern Virginia is associated, while from the similar nature of the sand and gravel in which they are embedded, we are entitled to conclude, that at least in part, they also refer themselves to the same region for their origin. In the hills at and below Richmond, and in many other places these beds of gravel have considerable depth, and present a structure at once curious and instructive. A series of strata at these places, in some of which the pebbles are disposed in horizontal lines; in others, in lines oblique, but still generally parallel, inclining downwards to various points in the different layers, give striking evidence of the agency of those diluvial and oceanic currents, of which geologists have discovered so many memorials in other regions, and may serve when minutely studied, to throw much light on the physical changes to which this portion of the continent must formerly have been subjected.

Beneath these beds of gravel, in many places strata of clay occur; but whether referable to the same epoch of deposition, cannot as yet be clearly ascertained. Many beds of very argillaceous clay, suited for the potter and brickmaker, and occasional layers of a pure beautiful yellow ochre, may be placed in this portion of the series.

Other strata of clay and sand of a peculiar character present themselves in many localities beneath the superficial beds. These contain a record of their origin legible to the geologist, in the impressions of shells and Zoophytes with which they are generally filled. On comparing these casts, which in most cases can be easily recognised even in their more delicate markings, with the fossils of our Miocene marl strata, their identity is established, and thus the strata in question at once take their places in the series of Miocene Tertiary deposites. In many parts of Hanover, King William, Henrico, and other counties in this range, these beds of clay are found, usually characterised by a dark greenish gray or brown colour, a sulphureous odour, and an astringent taste. On Governor's hill in Richmond, a stratum of the same kind is exposed; and at this spot, the fossil impressions and other characters above noticed, may be distinctly seen. Like the clays and sands formerly described as associated with the Miocene, these contain sul-

phate of iron (or copperas,) sulphate of alumina (or alum,) and sulphur in an uncombined condition. So large a proportion of these substances is sometimes present, as to render the water obtained from the strata in which they exist, absolutely unfit for use.

It is to the existence of these materials in the strata, that we are to look for the cause of the disappearance of the calcareous matter, in the form of shells, which they once evidently contained. Either of the sulphates above named would exert a rapid decomposing action on the carbonate of lime, of which shells principally consist. The sulphuric acid of the sulphate combining with the lime of the carbonate, thus converting it into gypsum, while the carbonic acid would, in great part, escape in the form of gas. That the gypsum is not now discovered in these beds, is an obvious result of the comparative solubility of that substance in water; its continuance in the strata being only possible where a heavy covering of clay excluded the percolating liquid.

Useless, if not injurious, as these clays are now believed to be when applied to land, there is reason to think that they are capable, by a little application of chemical knowledge, of being rendered truly valuable as an auxiliary manure. The gypsum into which their enclosed shells were once converted, would doubtless have imparted to them a high agricultural value. Can we not replace, if not all, some portion of this fertilizing material, by mingling the clay with the more pulverulent shell marls occasionally found in its vicinity? That this mixture would result in the conversion of a portion of the shelly matter into gypsum, there can be no doubt; and where the clay was originally rich in copperas and alum, the amount of the gypsum thus compounded would be proportionally great. Experiments on this subject are well worthy of being tried, not only with the clays here mentioned, but with those of a similar nature, which, as already remarked, occur in the more eastern portion of the Tertiary districts of the state.

Before the *amount* of *gypsum* to be anticipated from such a treatment of these materials can be estimated, a chemical determination of the proportion of sulphates of iron and alumina must be had, and to this point future analysis might be usefully directed.

But though much of the Miocene marl in this district has been exposed to the destructive chemical agencies above explained, much

also is found retaining its carbonate of lime in undiminished quantity.

On the lower levels on the river banks, it appears seldom to have escaped the dissolving and decomposing action of the sulphates, while in the highlands it may usually be found containing its calcareous matter nearly as when first deposited. In King William, Hanover, Prince George, &c., beds are found in the highlands, at some distance from the rivers. The fossils they contain are identical with those of the marl beds farther east, and the materials with which they are intermixed present no peculiarity important to be remarked. Specimens of this Miocene from Hanover, King William and Prince George, exhibit a good per centage of the carbonate of lime, and as might be expected, the strata from which they were taken are usefully resorted to by the neighbouring farmers.

As would be inferred from remarks previously made, the general level at which this marl occurs, is higher than that of the Eocene, and here the promise is held out that this latter, even in the highlands, would be exposed by excavations carried to some depth beneath the lower limits of the former.

In examining the Eocene deposite on the Pamunkey and James rivers, the interesting geological fact was observed of an *actual superposition* of the Miocene upon it; and on the Pamunkey, the precise point was determined at which the Eocene first makes its appearance above the water-line, being there overlaid by a heavy bed of the more recent deposite. This occurs at Northbury, and directly opposite at the plantation of doctor Charles Braxton.

OF THE EOCENE OR LOWER TERTIARY MARL.

The descriptions and facts which will be comprised under this head, will principally refer to the localities on the Pamunkey and James rivers, to which especial observation has been directed. At the same time that their value, as applying to the Eocene district generally, may be regarded as being sufficiently established by general geological analogies, as well as such observations upon other portions of the region, as the present early stage of the inquiries has allowed me an opportunity of making. No region of eastern Virginia holds out more certain promise of reward to future investigation, and none will reap from the research more lasting and important benefits.

DESCRIPTION OF THE EOCENE STRATA OF THE PAMUNKEY.

Rising above the water-line at Northbury, the upper surface of the deposite is seen ascending with a very gentle slope, as it extends higher up the river, until at Newcastle it attains an elevation of about 25 feet above medium tide. Beyond this point, with slight undulations in its outline, it continues with but little general deviation of height from the water-line to near its termination at the junction of the North and South Anna, where it dips or thins out until lost immediately on the verge of the coarse sandstone, which there, for the first time, makes its appearance in massy form. The deposite appears on both sides of the river, wherever the flats do not intervene, and at the base of the second level, corresponding in position to its place in the river cliffs in the same vicinity.

On the south side of the river, the deposite has been particularly examined, at Northbury, Hampstead, Retreat, Washington Basset's, Walker Tomlin's, Mrs. Ruffin's, Mr. Roane's and Mr. Wickham's, where it terminates. Specimens have been collected from other localities, either on the river or at the base of the second level: on the north side, at Chericoke, captain Hill's, Mr. Nixon's, Piping Tree, Newcastle, Dr. Braxton's and Mr. Fox's. Specimens also from various other points on, and remote from the river, have been procured, and thus a somewhat minute acquaintance with this portion of the Eocene tract has been attained. Towards the southern boundary of the deposite, the following arrangement of strata occurs, commencing at the top.

1st. A stratum of greenish yellow earth containing no shells, but numerous traces or casts of them, plainly showing that shells were at one time embedded in the mass. Sulphate of lime or gypsum occurs in crystals sometimes of considerable size, interspersed throughout this stratum, which is principally made up of coarse silicious sand, blended with granules of greensand or silicate of iron. The thickness of this bed is variable; at Chericoke and Hampstead it is about two feet; at Retreat from four to five.

2d. Beneath this lies a layer of dark greenish blue or brown earth, which when dried, generally falls to pieces, and is discovered to consist mainly of coarse silicious sand, and greensand, together with shells generally in a broken condition. The shelly matter is sometimes entirely wanting, though occasionally it composes a large por-

tion of the mass. At Hampstead, the calcareous ingredient exists in large proportion and in a finely divided state. Frequently, one or more thin layers of the oyster shell peculiar to the lower tertiary region occurs in the body of this stratum; a fact remarkably exemplified at Piping Tree, and for nearly a mile further down the river, where the layer of shells froms a hard rocky shelf laid bare at low tide, and presenting large and perfect specimens of the fossil oyster, in the midst of the greenish stratum just described.

At Chericoke the stratum rises to about four feet above the water, and as ascertained by digging, descends to seven feet below the river shore.

Higher up the stream, these strata attain a greater elevation, and subjacent beds, not apparent at either of the points above described, come gradually into view. In these localities we usually find,

1st. A layer of dark grayish-green or grayish-brown colour, containing multitudes of shells, generally in a perfect state; the fossil oyster shell already referred to abounding chiefly in the upper part of the stratum. Beneath this, but frequently separated by no distinct line of demarkation, we find,

2d. A layer of darker hue, containing less shelly matter, and the shells chiefly of the smaller kinds; and

3d. A stratum of the same appearance, in which no calcareous matter can be discovered.

All these strata contain a large portion of the greensand. In the upper and lighter-coloured beds, the granules of this substance are very obvious to inspection, resembling in size and colour the grains of gunpowder, and giving when bruised a bright green stain. In the lower beds they are more minute, and being intimately mingled with the other materials present, are not readily recognised, excepting by the general greenish character of the mass. These beds also contain a great deal of Mica in fine sparkling scales. Of the depth of these strata below the level of the river nothing definite is known, no extensive excavations having yet been made. At Mr. Wickham's they are found to rest upon a layer of large pebbles, but this basis is perhaps not co-extensive with the deposite lower down the river.

When the upper bounding surface of the Eocene is even and uniform, it is always marked by a *thin layer of black pebbles*, upon which there usually rests a bed of olive-coloured earth, or of friable

white clay,—and in some cases, both these strata, the olive-coloured being next the Eocene.

This olive earth is of a fine texture, containing but little gritty sand. Here and there a shark's tooth in a decomposed condition, or the impression of a shell may be discerned. The white stratum abounds in casts, but never presents the shells themselves. It shows a light trace of gypsum, but in neither of these beds does there exist any carbonate of lime. From the character of the organic impressions they contain, they clearly refer themselves to the Miocene formation.

In some places on the river, particularly where the upper bed of the Eocene contains gypsum, as at a point a little below Piping Tree, a thin layer of ferruginous rock abounding in casts occurs immediately in contact with the Eocene; this also is to be placed among the strata of the Miocene.

A more distinct conception of the order and extent of the strata of both the tertiary divisions, as they occur at different points along the river, will be obtained from the following summaries derived from observation.

On the north bank of the river in a cliff about half a mile below Piping Tree, the beds taken in a descending order are,

Miocene.—	1. White friable sandy clay, containing fossil impressions, - - -	10 feet.
	2. White sandy marl with broken shells, -	½
	3. Ferruginous stratum abounding in casts, and occasionally containing the shells themselves,	½
	4. Thin band of black pebbles.	
Eocene.—	5. Dark greensand stratum—no shells, -	4
	6. Rocky shelf of cemented shells of the saddle-shaped oyster, - -	½
	7. Dark greensand strata with small shells, -	2
		17½

The highest Miocene bed is not exposed at this point, but occurs a little farther up the river in the character of a dark blue clay with fossil impressions, on which there rests a thin layer of ochreous clay, as brilliant in its tints as the finest chrome yellow. This ochre is of the most impalpable texture when dried, and would be found very valuable in colouring.

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At Mr. Washington Basset's, about 4½ miles higher up the river, the bank is precipitous, and presents the following series of strata:

Miocene.—Superficial gravel,	- - -	5 or 6 feet.
	Thin layer of friable sandy clay with casts, -	½
	Olive-coloured earth with shark's teeth, and a few casts of Miocene shells, - -	7
	Thin line of black pebbles.	
Eocene.—Dark greenish-brown stratum, containing a large proportion of greensand, and in some parts abounding in shells. The upper portion consists of a rocky mass of cemented shell, chiefly the saddle-oyster, - -		20

At Walker Tomlin's, on the south side of the river, immediately below Newcastle, the beds are,

Miocene.—Friable white clay and sand with casts of shells,		2
Eocene.—Olive earth with pebbles at bottom, - -		6
	A dark bluish-green clay, containing a great deal of greensand, capped by rock as at the former locality, - - -	25

At Newcastle and William H. Roane's and Mrs. Ruffin's estates, a similar series of beds occurs, rising still higher above the level of the stream. About 1½ miles above Newcastle, the upper surface of the Eocene marl has an elevation above the river of more than thirty feet. The lower stratum consists of the bluish-green clay before mentioned, containing only a few of the more delicate shells, and richly abounding in greensand; the upper of a gray calcareous marl, thickly speckled with granules of this substance. Over the whole is a layer of the white friable material, with Miocene impressions.

The upper surface of the Eocene usually presents an unbroken line, though at some places, as at Mr. Fox's above Newcastle, this is not the case. The bed here consists of a light-coloured sand and clay, speckled with the greensand, and containing vast numbers of the Eocene oyster. Its outline presents numerous cavities and eminences, exactly resembling those which occur in the Miocene deposite nearer to the seaboard. A narrow layer of common sand

deeply tinged by mixture with greensand, lies immediately upon this irregular surface, and the whole is covered with a bed of gravel and sand, with diagonal lines of stratification, indicating the agency of currents at the time of its deposition.

At Mr. William Wickham's, the overlying stratum consists of bands of ferruginous gravel and sand, containing round concretions, like Geodes, generally filled with sand. Thin seams of iron ore run along this stratum a few feet above the fossiliferous beds. These latter, in some places, present a level outline, and are then always covered by a layer of sandy clay containing much greensand. On the other hand, where the outline is undulating and irregular, a stratum of gravel rests immediately in contact with the bed of marl. The size of the gravel thus deposited, as well as the scooped surface of the bed on which it reposes, indicating the operation of powerful currents after the deposition of the strata of Eocene, presents an explanation of the absence in these places of the upper bed of this formation, remarked as present in those spots, where there are no such indications of the action of destructive forces. The matrix of the fossils is sometimes an olive-coloured clay, sometimes a grayish-green sand and clay, and sometimes a bluish-black clay, containing a large proportion of the granules of greensand. The depth of the marl is 15 feet.

EOCENE STRATA OF THE JAMES RIVER.

The beds of Eocene on the James river first make their appearance on its southern shore near Coggin's Point, and thence continue, except when interrupted by the river flats, to a small distance above City Point, making a distance following the flexures of the shores of about ten miles. On the opposite side they have been found at Berkeley and other points, but as yet this portion of the deposite has been but little examined.

At Coggin's Point, Tarbay and Evergreen, the cliffs have a height varying from 30 to 40 feet. The Miocene marl, which in some places is seen overlying the Eocene, abounds in scallops and other shells which make it easily recognised. Beneath this and usually separated from it by a thin line of black pebbles, like those occurring on the Pamunkey, there occurs a stratum of a greenish-red and yellow aspect, containing much greensand and gypsum; the latter partly disseminated in small grains, and partly grouped in large and massive crystals. The under stratum, rich in greensand and con-

taining a few shells in a friable condition, extends to some depth beneath the level of the river, and appears to rest upon a bed of clay of a lead colour, containing crystals of gypsum. At Evergreen a stratum of pure white clay rests upon the upper layer of Eocene, containing, embedded in its lower surface, large groups of crystals, and seems to occupy the place of the black pebbles before mentioned. The whole thickness of the Eocene deposite at this point appears to be about twenty feet. Below as well as above this place, its height declines until no portion of it is any longer visible above the water edge.

EOCENE DEPOSITE OF THE POTOMAC, RAPPAHANNOCK AND MATTAPONY, &C.

Although the shores of these rivers have as yet been but little examined with a view to the structure and arrangement of the various strata they exhibit, enough has been observed to prove that they are no less rich in the Eocene marl than the other districts which have been described. On Potomac creek, and for a great distance below its mouth, the greensand strata may be seen running along the base of the cliff; and from specimens examined, there can be no doubt that the character of the deposite is similar to that of the Eocene of the James river and Pamunkey. On the Rappahannock, for a considerable distance below Port Royal, the very same appearance is presented; and the greensand obtained from some of these localities is in every respect like that from the points already noticed. In some places on the Mattapony, the occurrence of the greensand stratum has been ascertained, while in others the beds containing this substance are replaced by beds of clay, which, though geologically of the same (or Eocene) formation, are yet less likely to prove interesting to the agriculture of the vicinity. Minute inquiries throughout all this district, and throughout the corresponding region south of
the James river, are alone capable of developing the e
lue of this deposite. Even a great deal yet remains to l
vestigating localities on the James and Pamunkey rive
ern shore of the latter being so far almost unexplored,
cise character and value of some of the beds in locali
being but imperfectly ascertained.

In treating of the accompanying Miocene in the beginning of this section of the report, our descriptions have been confined chiefly to those beds which occur remote from the rivers upon the highlands, and no mention has been made either of the white friable sand or olive-coloured clay already frequently noticed in describing the overlying strata on the Pamunkey.

The first of these, though once the repository of shells and other fossils, is now entirely destitute of carbonate of lime. A small quantity of gypsum in a minutely divided state seems to be its only ingredient of any value, and the amount of this present in the specimens I have examined is much too inconsiderable to give the material any agricultural importance.

The olive earth, which is frequently an extensive layer, has also lost all the calcareous matter which it once contained; but a further examination, chemical and geological, of this material, will be required before its nature can be exactly determined, or the possible applications of which it may admit can be ascertained.

The upper bed of the Eocene, characterised in most of the localities by the gypsum which it contains, is worthy of especial consideration on account of this valuable ingredient. In specimens from the James river, from five to eight per cent. of this substance has been found in a divided state, at the same time that a considerable additional quantity in a massive form exists in various parts of the same stratum.

On the Pamunkey this stratum is not so thick, and is perhaps less abundant in the sulphate of lime. The lower beds, in some cases containing a marked proportion of shelly matter, and in others having almost none, are more especially distinguished by the larger proportion of another and even more important ingredient, to wit, the greensand. Both on the James river and the Pamunkey, their richness in this material gives them an agricultural value which perhaps no proportion of calcareous matter by itself, however great, would be able to impart. The illustrations of its beneficial effects, and the general observations upon its employment as a manure or marl, which will hereafter be presented, will, I think, manifest the justice of this opinion, and give a sound confidence to those who are disposed to make trial of its powers.

EXTENT AND COMMODIOUS POSITION OF THE EOCENE ON THE RIVERS.

One of the most interesting facts presented in the foregoing description of the Eocene on the Pamunkey and James rivers, is the great depth and extent of those strata, which, from the nature of their contents, may be applied to profitable use in agriculture. Beds of such materials, preserving an average thickness of twenty feet, extend along the banks of the Pamunkey with occasional interruptions for more than twenty miles.

Their position on the river shore makes them of most convenient access, and gives additional facilities to the conveyance of the fertilizing materials they furnish to various distant points, while from the peculiar character of the strata themselves, they are almost exempt from the usual destructive agencies of the freshets, being of a texture to withstand with scarcely any loss the most violent assaults of the sweeping currents by which the banks of the river are so often overflowed. To this cause we are to ascribe the steep declivity of the shores in many narrow parts of the river, where the abrading action of the water, instead of rapidly carrying off the materials of these strata, has merely served to wear them into smooth and almost perpendicular precipices rising immediately from the margin of the stream.

EXISTENCE OF THE EOCENE BENEATH THE HIGHLANDS, AND THROUGHOUT THE WHOLE BREADTH OF THE STATE.

The general position and direction of the Eocene beds suggests another view of great practical importance to this and the neighbouring districts of the state. I allude to the probable, perhaps I may say certain, continuation of these strata over a wide area, on a level corresponding to the general depth at which they are found upon the rivers. In confirmation of this view it may be remarked, that since the publication of a communication on this subject in the Farmer's Register, the existence of a similar deposite throughout an extensive district of Maryland, lying in the general direction of our Eocene formation, has been brought to light, and there is reason for believing that within the borders of North Carolina, near to the Virginia line, the same strata are displayed in the banks of several of the streams. In the belief then that all this extensive band of country, stretching in a meridional direction entirely across the state,

rests upon strata of this description, we are led to regard it as furnishing an immense addition to the resources of the state, and as holding out to our enterprising farmers situated within its limits, a new motive to persevering and active research. Let it not be supposed, however, that wherever the Eocene occurs within our state, it will be found to present the same materials in the composition of its strata, as have been found in the localities already examined. Much diversity in this respect may, and probably does exist. On the Mattapony, as already stated, the greensand is frequently replaced by beds of clay of a dark lead colour; while on the Potomac, Rappahannock, Pamunkey and James, variable but generally large proportions of the greensand occur, and the probability is, that future inquiries will develope similar diversities in the materials of the beds in other yet unexplored portions of the district. Constancy in the character of the embedded fossils is all that is necessary to a geological identity of the formations, and this constancy may exist at the same time that there is a considerable diversity in the materials in which they are enclosed. It is almost certain, however, that throughout a large portion of the region in question, extensive and valuable beds containing the greensand do exist, and that even in the highlands they might be reached by excavations descending not very far beneath the lower limit of the Miocene or ordinary marl.

ON THE VALUE OF THE EOCENE GREENSAND MARL IN AGRICULTURE.

From the descriptions already given of the materials of the various beds of Eocene, it will be seen that many of them contain ingredients which have long been recognised as valuable when applied to land. The gypsum in some, and the carbonate of lime in others, will at once bespeak the favour and confidence of the agriculturist, and no observations, either as to their usefulness or mode of application, will be necessary to give them the importance they deserve. But the *characteristic and principal* ingredient of a large number of these beds, the *greensand*, possesses claims to our attention which are equally indisputable, though not so generally appreciated or understood. Experiments within our own state on this material, as furnished by the Eocene deposites, though few, and on a very limited scale, have been so far satisfactory. But as the marls containing this substance, which have been employed, have also in most cases contained a notable quantity of gypsum, or of calcareous matter, all

the benefits which they have produced would most naturally and reasonably be ascribed to those ingredients, already known for their agency in ameliorating the land. On the Pamunkey the Eocene marl has long been in use, but chiefly those beds have been selected for the purpose of marling in which the largest proportion of calcareous matter was seen to exist. The lower layers, containing little or no calcareous matter, have on that account, until lately, been rejected as useless, and sometimes when a bed of this description of considerable extent was found immediately overlying a more shelly stratum, much trouble and expense have been incurred in its removal, to make way for the excavation of the material beneath. Appealing to the experience of the farmers of New Jersey, by whom the greensand, in an almost unmixed condition, has long been applied for the purposes of a manure, its unrivalled efficacy, and the permanency of its ameliorating effects, are to be regarded as established and unquestionable facts. It is true, that at one time, owing to the ignorance of those who attempted to make use of it, and the application frequently of a spurious material resembling it in aspect, doubts of its value have been excited in the minds of some; but the extensive and uniform experience of the present enterprising farmers of that state, gives an unqualified testimony to the rapidity, the power, and the durability with which it acts.

A comparatively small dressing of this marl, often not exceeding ten or fifteen loads per acre, is uniformly attended with beneficial results, and this, whether the soil to which it is applied, be a clay, or a light sterile sand. As an illustration of this fertilizing property of the greensand, I will subjoin the following statement quoted from the report of my brother, Professor Henry D. Rogers, on the geology of New Jersey, to which work I beg leave to refer, for ample and satisfactory details relating to the agricultural value of this substance, as well as for practical suggestions as to the most judicious modes in which it may be applied:

"When we behold a luxuriant harvest gathered from fields where the soil originally was nothing but sand, and find it all due to the use of a mineral sparsely disseminated in the sandy beach of the ocean, we must look with exulting admiration upon the benefits upon vegetation, conferred by a few scattered granules of this unique and peculiar substance. The small amount of greensand dispersed through the common sand, is able, as we behold, to effect immeasurable benefits in spite of a great predominance of the other mate-

rial, which we are taught to regard as by itself so generally prejudicial to fertility. This ought to exhibit an encouraging picture to those districts not directly within the limits of the marl tract, where some of the strata possess the green substance in sensible proportion. It expands most materially the limits of the territory where marling may be introduced, and points to many beds as fertilizing, which otherwise would be deemed wholly inefficacious."

If such then be the effects of this material, even under circumstances where comparatively little advantage could have been anticipated, and if such moreover be the concurrent experience of those by whom it is daily and extensively employed, we are fully authorised in the belief, that in the Eocene beds of our own state, though in general less rich in the fertilizing ingredient than the secondary strata of New Jersey, the agriculture of eastern Virginia possesses a new and most valuable resource.

The chemical examination of these marls, with a view to precise results, being a matter requiring much time and labour, has as yet been carried on only to a small extent. But, a thorough analysis of all the important varieties and an exact determination of the proportion of the various constituents, especially the greensand, or the calcareous matter in different localities, will be a work from which much practical good may be derived. By the light of such results alone, can the farmer be safely directed in applying it to the soil, or be properly guided in distinguishing between a material which is spurious, and one which will be found salutary in its effects upon the land.

The following results are to be looked upon as approximate determinations, but will serve to illustrate the composition of several varieties of the marl:

COMPOSITION OF GREENSAND (EOCENE) MARLS.

Doctor Corbin Braxton's,	Silica and alumina, &c.	50
	Carbonate of lime,	10
	Greensand,	38
	Gypsum,	2
Walker Tomlin's, lower stratum,	Silica and alumina,	60
	Carb. lime and gypsum,	*a trace.*
	Greensand,	40
Conrad Webb's,	Silica and alumina, &c.	30
	Carbonate of lime,	45
	Greensand,	25

Wm. H. Roane's, lower stratum,	Silica and alumina, &c.	50
	Carb. lime,	4
	Greehsand,	46
	Gypsum,	3
Tarby, lower stratum,	Silica, alumina, &c.	40
	Carb. lime,	3
	Greensand	57
Do. upper stratum,	Gypseous earth containing from 6 to 10 per cent. of gypsum, and from 10 to 15 per cent. of greensand.	
Berkeley,	Silica and alumina, &c.	50
	Greensand,	50

Viewing these results generally, it is apparent, that while in some cases the efficacy of the marl would be ascribable in a degree to the calcareous carbonate or sulphate present in large proportion, in a great many others the greensand ought to be regarded as the chief, if not the only agent in the effects. A dressing of many of these marls to the extent usual in the application of the Miocene shell marl would scatter upon the soil a proportion of greensand, nearly as great as the average quota which is at present in use in New Jersey, and in the richer sorts, a much less proportion would be necessary than it is customary to apply where the shells abound.

We are struck, in considering the composition of these marls, with the happy variety of constitution which they exhibit, which, should there be any specific action of the respective ingredients on particular vegetables, which there is reason to believe is the case with one (the gypsum,) will the more completely adapt them to the variety of crops to which the farmer would wish them to be applied.

Some caution will be necessary in distinguishing the marls, containing a large proportion of greensand, from dark greenish clays and sands, which have sometimes been mistaken for them. These clays are always entirely destitute of fossils; they have an astringent or copperas flavour, and generally a strong sulphureous odour, though a slight smell of this kind is also often observed in the best marls. The occurrence of small shells sparsely distributed and in a decomposing state is very frequent in the good marls, though an almost total absence of shells is sometimes observed. Fine sparkling scales of Mica, (not gypsum, as supposed by some,) are generally present in considerable proportion, and have led those who speculated upon

the action of the marl, to ascribe a large part of its efficacy to the supposed sulphate of lime or gypsum contained in it. To distinguish a marl of this kind from the dark blue Miocene marl, a slight attention to the embedded fossils will be sufficient. The saddle-shaped oyster, characteristic of the Eocene, and never found in the later deposite, would at once determine the bed in which it is found to be of the former description—while the common scallop or clam, which is never seen in the Eocene, would indicate the Miocene character of the bed in which it lies.

In concluding what I have to say upon this important topic, I may be permitted to throw out the suggestion, that should the deposite of which I have been treating, be found as extensive in its range and as useful as a manure as here anticipated, the districts of the state contiguous to its western limits, as well as the region in which it occurs, might be expected to reap important benefits from its employment. Parts of Henrico and Hanover, and the lower part of Louisa, in which no marl exists, would be sufficiently contiguous to the Pamunkey deposite to avail themselves profitably of its use, and when the projected improvements in this region of the state shall present cheaper and readier means of transportation to the remote parts of the two latter counties, as well as to a portion of Goochland, it is not extravagant to hope that this material may be conveyed to those districts at such a cost as will render it a profitable as it would be an efficacious restorative to the exhausted and sterile soils to which ameliorating applications have of necessity hitherto been denied.

To other parts of the state in a corresponding position, perhaps similar benefits might be dispensed, and thus most of that portion of the state beyond the reach of the limestone which ranges a little east of the S. W. mountain, would in time be brought under the beneficent influence of the marls of the western limits of the Eocene formation.

REGION BETWEEN THE HEAD OF TIDE AND THE WESTERN FLANK OF THE BLUE RIDGE.

The various geological features of this extensive division of the state are peculiarly interesting, and at the same time difficult of investigation. To trace the limits of the formation of an undoubted primary character, occupying the region towards its eastern border, and to ascertain the extent of the overlying rocks, connected with

the valuable bituminous coal of eastern Virginia, is of itself a task in which much time and industry could be advantageously employed. To investigate minutely the relations and character of the various rocks with which the auriferous quartz of the region adjacent to the western limits of the former, is associated, and to ascertain the number, direction and relative value of these veins, so productive in the precious metal, would also be a business requiring much laborious and discriminating observation; while, in the remainder of the district of which we are now treating, multiplied and accurate researches, directed to numerous lines across its surface, would be indispensable to correct views of its geological details; to the removal of the many obscurities in which its structure in numerous points is as yet involved, and to the really useful developement of its great mineral and agricultural resources. In the brief period allotted to the reconnoissance, therefore, the attainment of much minute knowledge regarding this region was not to be anticipated, although while aiming at the determination of interesting points of general inquiry, it was always deemed an important object to collect useful details, calculated to throw light upon the resources as well as the structure of this region.

Before entering upon the description of the strata of primary and other rocks of a very ancient character, of which this region is in the main composed, it will be most convenient to treat of the interesting formations, including the bituminous coal of eastern Virginia as well as of the sandstones overlying the tide water borders of the primary.

GEOLOGY OF THE BITUMINOUS COAL FIELD INCLUDED IN THE PRIMARY REGION.

Of the extent and exact geographical limits of this truly interesting coal formation of eastern Virginia, too little is yet known to warrant more than a few words to designate its general position and relations to the other strata. We shall dwell, however, upon one or two points connected with its internal structure, of great moment to all those who are interested in the further developement and working of its coal seams.

It will be apparent by a reference to the general profile or geological section across the state, that the sandstones and their associated coal seams, which make up the formation before us, rest in a narrow trough in the primary strata. Whether the

group is characterised by containing coal to a greater or less amount throughout its whole extent, is yet a question, and one which can only be determined after minute and elaborate investigation. Traces of good bituminous coal are detected at intervals over a space of nearly 35 miles in length, from the South Anna near its mouth to near the Appomattox river; but there is nothing to assure us that the sandstone in which the coal occurs, does not range, at least in some directions, beyond the limits where the coal itself thins away and disappears. Towards the central part of the formation,—namely, within a few miles on either side of James river,—the coal appears to be thickest; and it is there accordingly, where the deposite has alone been worked, that we can collect facts enough to lead to any general views of a practical bearing regarding the structure of this coal field. Where our section crosses it,—namely, through the estates of Mr. Wickham on Tuckahoe creek,—the width of the coal tract is about four and a half miles. It seems to expand in width as we follow it to the south side of James river, being in a section drawn through the Black Heath mines, probably eight miles across from the eastern to the western outcrop of the primary strata, which compose the floor upon which the coal-bearing group reposes. The probability is, that this is nearly the centre of the basin, and the widest part of it, if we are to judge from the fact, that the coal exists in greater thickness here than at any place either further north or south.

The thickness of these coal seams is very variable; the great lower mass which reposes within two feet of the primary rock, in the Deep shaft and other adjacent mines in Chesterfield, is estimated to be 40 feet from its upper to its lower surface. Over this there is another thinner seam, five or six feet thick, separated by a few feet of coal shale. A third, still thinner band of coal, is found between these in some of the mines. Upon the opposite or western side of the basin, two separate seams are wrought in several of the mines. At Anderson's mine, the upper seam varies from from six to sixteen feet in thickness—the lower, separated from it by 30 feet of slate and sandstone, is from four to eight feet, and rests almost immediately upon the top of the primary rock. At Willis' and Crouch's mines, on the south-east side of the coal field north of the river, there are also two principal seams, the upper being five feet, the lower about four feet thick, and separated from each other by 11 feet of slate. In both these points as elsewhere, the upper seam

is invariably the purest coal. We have thus, at a distance of nearly 10 miles from each other, two localities, showing sufficient correspondence in the relations of the seams to each other and to the adjacent strata, to establish the continuity of the same beds across the whole coal field.

In some of the shafts on Tuckahoe creek, as many as five separate seams have been struck, of thickness sufficient to justify working, and there exist many more of insignificant dimensions which are neglected. There are good local reasons in several parts of the coal field on the north side of the river for believing, that the seams occasionally coalesce, so that two become but one.

We do not conceive it essential to the objects of the present report, to specify anything more respecting the local details of the numerous mines in this coal field, than is requisite to make its importance and peculiar structure understood.

On the south side of the James river, an old mine, called the River pit, now deserted, contained at the depth of 130 feet, a seam of coal 20 feet thick, but which, owing to a close approach of the granitic floor to the sandstone roof, was so reduced in thickness as to be abandoned.

Upon the east side of the same portion of the basin in Mills' mines, the coal varies rapidly in thickness, from almost nothing to upwards of 40 feet, and in one place to sixty feet, if we include thin bands of the coal shale. In the Midlothian pit the shaft is 500 feet in depth, and the workings are carried to the depth of 700 feet below the soil. The coal is very variable in thickness, being worked at more than 30 feet, and in some places it is even thicker. In this mine, as in several of the adjacent ones, we have numerous instances of the coal filling up hollows as it were in the floor, being accumulated in saucer-shaped basins to the thickness of 40 or 50 feet, and resting in comparatively thin masses upon the *eminences* in the same floor. In some instances, these subordinate basins are almost entirely insulated from the rest of the coal field, and are presented under features which preclude us from supposing that they owe their shape exclusively to the numerous faults which intersect the strata. Upon the north side of the river near Tuckahoe, the coal was reached precisely in the centre of a small insulated cup-shaped depression. The coal as it was pursued, was found to rise gently on all sides from the shaft, and also to thin away from a thickness of four or five feet to two feet towards the edges of this shallow basin,

which was several hundred feet in diameter, and but little disturbed from its original nearly horizontal position.

It should be remarked, that while the under surface of the coal resting almost in contact with the primary rock, assumes its unevenness of outline, the upper surface is also affected by similar undulations, though to much less extent, which only goes to show that the deposition of the coal did not sufficiently fill up the original inequalities upon the floor, to make a perfectly level surface for the reception of deposites which succeeded.

Of the nature of the dislocations or faults, too little is at present known to enable one to generalize or say much upon this truly important topic. The greatest number of pits being upon the eastern border of the coal field, it is there that the faults or troubles, as they are generally denominated in this region, are best seen. Along this outcrop of the coal, there would seem to extend over a great space one or more very remarkable lines of dislocation, throwing up the coal to the west by a heavy fracture, so as to make of the same seam a double outcrop, and over a distance of perhaps half a mile, bringing the subjacent granite itself again into view. We witness, therefore, over a portion of the eastern side of the coal field, two parallel ranges of collieries, less than a fourth of a mile asunder. The Black Heath mines, the Union mine and the Deep run pits are said to lie along the outer crop, though it is questionable whether one and the same fracture extends over so many miles of strata. The probability is, that several nearly parallel fractures will be found traversing this side of the region, and tending to the intricacy and difficulty of successful mining. In fact, three extensive faults affect the strata near the Black Heath mines, the outer one causing the upthrow before stated, and the others producing heavy downthrows to the west.

It would seem, that transverse to these more important and serious fractures, which generally pursue a direction nearly parallel to the general line of outcrop of the coal, there are innumerable other more trivial breaks and displacements, sometimes straight, but oftener irregular in direction and dip, which still further intersect the strata, dividing them into a multitude of nearly detached and broken basins. An exact knowledge, more particularly of the great longitudinal faults, is especially desirable for directing with system the mining operations of this coal field.

There is one general fact of much practical interest disclosed in

nearly all the principal mines of this whole coal field—It is, that the main body of the coal lies either in direct contact with the primary rocks, or closely contiguous to them. This furnishes a highly important guide, or in fact the only unerring one, in the prosecution of new or intricate workings; for, it suggests the utility of making the primary rock the object towards which the mining should be pursued whenever a difficulty occurs in regaining the coal displaced by a fault; for, if we are surrounded by sandstone, we may be sure that the chief deposite of the coal is to be reached by penetrating across the strata towards the subjacent granitic floor.

The sandstones being all of them nothing more than the debris of the subjacent primary strata recemented, they resemble them occasionally so much as to render it difficult to the inexperienced to distinguish the two classes of rock; though the discrimination in this case is all important. The aid of a pocket magnifier will detect a less angular character in the materials of the sandstones than in those of the primary rock.

The general range or longitudinal direction of the coal field, or what is the same thing, the line of bearing of the outcrop of the coal, is nearly N. N. E. and S. S. W. The structure of the coal field is that of a true but very oblong basin, composed of a thick series of variously constituted sandstones super-imposed upon two or three seams of bituminous coal, themselves resting almost immediately in contact with the surface of the primary rocks of the surrounding region. Wherever the eastern boundary of the coal field has been traced, the beds of gneiss or stratified granite are seen to dip apparently with considerable regularity to the west, or beneath the coal, and in like manner upon the opposite or western edge of the tract, the same rock is known to have a general dip under the coal to the east; suggesting the notion, at first sight, that the strata pass horizontally under the middle of the coal field. That this is not necessarily the case, will appear presently.

The usual angle of the primary strata to the horizon is about 25 or 30 degrees. Between the city of Richmond and the edge of the coal field at Tuckahoe pursuing a progress westward, the dip of the strata for the first several miles, is at a gentle angle to the E. and N. E. varying sometimes to the north. Near the coal, the point towards which the strata are dipping, is more nearly the N. W. or occasionally more west. A similar change of dip is seen in passing over the edges of the strata on the eastern side of the coal

field upon the Chesterfield side of the river. Tracing the dip of the gneiss rock westward, from the western outcrop of the coal, we find it to be towards the S. E., or beneath the coal field, and this throughout a width of several miles in our course west, until we approach the Beaverdam creek; here, for a short space, the dip is altered to the west, but the easterly direction is after awhile resumed, as we approach Goochland courthouse. Between five and six miles further on, or in the vicinity of Little Lickinghole creek, the dip is over more to the west. These various alternations in the position of the strata, are specified for the purpose of showing how probable it is, that the coal strata within the basin were originally deposited in a valley formed by the meeting of an eastern and western dip; in other words, upon the edges of the strata composing a *synclinal* axis, and not upon a horizontally placed stratum of the gneiss rock. The former view will help us more naturally to account for the very striking inequalities in the thickness of the bed of coal resting nearly in contact with the ancient surface of the primary rock. Had the ancient rocky floor, upon which the materials that formed the coal were deposited, been the gneiss rock in nearly horizontal stratification, it is hard to conceive how any subsequent dislocations of the whole group by upthrows and downthrows could introduce that remarkable degree of unevenness in the thickness of the coal seams over the small areas for which this coal field is so peculiar. Everything lends countenance to the opinion, that the surface of the primary rock, previous to the deposition of the carboniferous matter, was a valley of rolling outlines occupied by hollows and elevations, causing the first layers of matter which were thrown down to be deposited in greater thickness in some places than in others. As the lowest coal seam is separated from the crystalline rock beneath by only a very few feet of shale, and in some cases by none at all, it appears likely that the distribution of the coal was made unequal in thickness from the very commencement. There is ample proof that subsequently to the consolidation of an enormous thickness of sandstone over the coal, the entire series of beds, including the underlying primary strata, were reft by a number of extensive cracks, producing displacements of the beds, which combined with the original irregularity in the distribution of the coal itself, has caused the internal structure of this coal field to be one of excessive intricacy. These views are stated for the purpose of indicating the necessity of boring as the best and surest

means of ascertaining the value of particular parts of the formation. For it must be plain that the ordinary mode of mining, applicable to other coal fields, may be ruinously fallacious when applied to this. The intricacy of the faults, and the changing thickness of the coal, are features calculated to baffle and defy the anticipations of the miner. A profound knowledge of the nature and extent of the local disturbances around him, together with some general rules applicable to all coal mines, may enable him to approximate with considerable accuracy to the depth and position at which he is to meet the coal seam, but he can form little or no anticipation from knowing its thickness elsewhere, what its thickness will be when he reaches it in the new place. In most coal fields he may. The reason of the difference is, that in the present case the coal lies almost immediately contiguous to the undulating surface of the primary rocks below, and must partake, especially in its lower surface, of the plain upon which it was deposited. In most other coal regions the underlying rocks are either sandstones, limestones or slates, themselves originally horizontal deposites furnishing a level floor upon which the carboniferous matter would necessarily spread itself in an even sheet.

What is here said is not intended to throw a damp upon enterprise which is pursuing the developement of this coal field; on the other hand, we regard it as one of the most valuable deposites of mineral wealth within the area of Virginia. Our duty is by practical suggestions derived from the best sources within our reach, to promote a sound direction to the enterprise and capital employed upon the mineral resources of the state—to teach caution where necessary, but not to discourage.

The fine qualities of the coal in this coal field, both for domestic uses and manufacturing purposes, together with the very enormous thickness of the deposite in many of the mines where it is pursued, hold out an ample guarantee, that if prosecuted upon a correct conception of its internal structure, it must always prove a profitable region to the quarter of the state in which it lies.

There is one suggestion which we venture strenuously to enforce—the great importance of preserving specimens of the various layers of rock penetrated by the shafts which are sunk from time to time, or in any borings that may be made. The rocks resting above the coal are less liable to be affected by local variations than the coal itself, for reasons previously explained—and most important

inferences might be drawn as to the depth of the coal, by comparing the rocks as they are crossed in succession with sets of specimens of the same collected from the adjoining mines. Data will thus be rapidly accumulated, from which we shall one day be able to infer much better than at present, the extent of certain faults or downthrows, the nature of which can as yet be only imperfectly understood from the evidences produced in the workings of the mines. Nor is it too much to anticipate being able to compute from information thus derived, the depth from the surface of the coal in some places in the interior of the basin.

To show the constancy of certain layers of rock in particular districts, and their importance as a guide in particular situations, we may adduce a case given by Professor Phillips of a band of fossiliferous rock subordinate to a coal field in England. Speaking of a certain seam in the Yorkshire coal field, generally not much more than 16 inches in thickness, and traceable from near Leeds to the west of Sheffield, it is stated, "That it would have been impossible to have traced so thin a seam of coal along so extensive a range, without some peculiar facilities, some points of reference more distinct than the varying quality of the coal, and the still more irregular fluctuations of the sandstones and shales. This coal seam is covered by a 'roof' unlike that of any other coal bed above the mountain limestone in the British islands; for, instead of containing only the remains of plants or fresh water shells, it is filled with a considerable diversity of *marine shells* belonging to the genera *Pecten* and *Ammonites*, and in one locality, specimens of *Orthoceras*. The uniform occurrence of these Pectens and Ammonites through so wide a range, over one particular thin bed of coal, and in no other part of the coal strata, is one of the most curious phenomena yet observed, concerning the distribution of organic remains, and will undoubtedly be found of the highest importance in all inferences concerning the circumstances which attended the production of coal."

We may gather from this the importance of inspecting the sandstones for fossil remains, should any exist.

The mining shafts hitherto sunk in this region, have been confined exclusively to the vicinity of the eastern and western outcrops, from an apprehension, that more in the interior of the basin, the coal reposes too far from the surface to be readily reached. By following the banks of the James river above the mouth of Tuckahoe creek, it will be seen that the coal metals,—that is to say, the sand-

stones,—overlying the coal, after dipping throughout some distance at a moderate inclination to the north-west, become gradually almost horizontal, and continue so over much of the middle space between the eastern and western boundaries of the basin. This, certainly, implies the absence of any heavy dislocations affecting the middle tracts of the coal field, and is one feature calculated to support the notion of boring for coal in that quarter. From what has been said respecting the probability of an undulating surface in the subjacent gneiss or granitic rock, and of the faults which intersect the region, it becomes by no means improbable, that the coal in the centre of the basin will be found, in some places at least, sufficiently adjacent to the surface to admit of being profitably mined. General analogy would lead us to look for accumulations of coal in that quarter, if not thicker, at all events as thick, as can be seen near to either outcrop. But the resources of the middle portion of the coal field can only be imperfectly guessed at, until there has been gathered a much larger mass of minute information from the borders of the region. We do not yet know any thing definite regarding many portions of the limits of the basin, more especially the western outcrop—and there is moreover much to do in following the coal where it is already tolerably well known.

The deepest shaft, that of the Midlothian mine in Chesterfield, is 500 feet to the coal; and the workings connected with the same mine, in consequence of some very heavy downthrows to the west, penetrate to the depth of 700 feet below the surface. There is some reason to believe, that still further from the outcrop, there will be found an upthrow, bringing the coal once more nearer to the soil. It is possible that a shaft one thousand feet deep, would reach the coal in several places in the interior of the coal field.

In addition to the invaluable deposite above described, coal veins have been discovered in Prince Edward and Cumberland counties—and the rocks accompanying this mineral, are known to extend over a wide area in this portion of the state. Their thickness, compared with those of the coal fields previously described, is, however, not considerable—and the seams of coal which have been met with, though containing a very excellent material, are on a comparatively limited scale. The probable extent of coal in this district, appears as yet entirely undetermined, and will remain so until an examination of this portion of the state has been carefully and minutely made. The discovery of coal within a small distance of the base of Willis'

mountain, recently said to have been made, derives peculiar interest from the fact of the existence, in the same vicinity, of hematite and magnetic iron ores in great abundance.

SANDSTONES OVERLYING THE PRIMARY ROCKS ALONG THEIR EASTERN BOUNDARY.

Sandstones of various degrees of coarseness are found in many places along the eastern outcrop of the primary rocks, and extending for some distance below the head of tide. On the Rappahannock, in the vicinity of Fredericksburg, considerable exposures of these rocks are seen, the strata lying nearly in a horizontal direction upon the edges of the primary rocks beneath. At Falmouth, the two are seen in contact; the latter forming the bed of the river, and the former resting horizontally upon them. At the head of the Pamunkey, the same rocks appear, dipping with some steepness to the east; they are again met with, gently inclining in the same direction, a short distance below Richmond, and also in the neighbourhood of Petersburg, and at several points in Chesterfield county. Further south, they occur in the upper part of Greensville, and over a considerable portion of the county of Brunswick, and, as is believed, in portions of the adjoining counties.

In composition they are merely a mixture of quartz and felspar, in rather loose cohesion—the felspar often decaying rapidly on exposure. In some varieties, the rounded pebbles are not larger than birdshot; in others, they attain a diameter of many inches. In certain localities, the sandstone has a fine close texture, suiting it for various useful purposes, and is employed to a considerable extent in building. The quarries in the neighbourhood of Fredericksburg and Acquia creek, present beds of great thickness of a homogeneous rock of this description, of which extensive use has been made in some of the public edifices in Washington, Richmond, and elsewhere. In the superior portion of these beds, Lignites, silicified wood, and vegetable impressions, are frequently to be seen—all of which contribute to render the examination of these deposites a subject of much curious interest to science. Whether these sandstones be in reality contemporaries of the analogous, though somewhat differing rocks of the coal measures of eastern Virginia, impressed with peculiarities as to texture, and included fossils by some circumstance of position and exposure in the progress of their deposition

—or whether, as has been maintained, they are in fact of a decidedly more recent origin, are points only resolvable by cautious and diligent investigation.

In connexion with these sandstones and the rocks of the coal measures, there occur in several places beds of earth sometimes having nearly the firmness of a soft rock, containing a considerable proportion of calcareous matter. In Prince Edward, where their existence was first particularly remarked by Dr. Morton, these clays and semi-rocks are occasionally so liberally impregnated with this substance as to furnish a strong and valuable marl. At other points, a mixture of carb. of lime and carb. of magnesia is found in beds of considerable extent, and having a texture similar to the materials above described. According to an analysis of a specimen of this substance from Bear Island, it consists in 60 grains of

Carb. of lime,	31
Carb. of magnesia,	18
Alumina,	3
Silica,	7
Loss,	1
	60

The occurrence in many parts of this region, of clays and rocks thus abounding in calcareous matter, is certainly to be looked upon as a happy circumstance. Those interested in availing themselves of the fact, should have no difficulty in the application of these substances in the raw, or if necessary, in the calcined condition; for, even should they generally contain any notable proportion of magnesia, the more enlightened experience of the present day would seem to show that the presence of that earth is rather favourable than injurious when associated with lime, and in some cases almost equal in efficacy to calcareous matter itself.

There is moreover another economical aspect in which this material may be regarded. From the large proportion of magnesia it contains, it would furnish an admirable resource for the manufacture of that earth in the state of pure carbonate, or of what is at present an object of much more extensive commerce, I mean the sulphate of magnesia, or epsom salts.

much oxide of iron and some lime, produces when decomposed, a deep red earth, which, in virtue of its composition, is generally found productive.

In accounting for the highly ferruginous soils presented in many places in this district, as at Beaverdam in Goochland, it might at first view appear most plausible to regard them as the product of disintegrated hornblende, derived from the subjacent strata, and certainly in some localities the colour and qualities of the soil may be justly referred to this origin. But there are numerous instances in which the superficial earth or clay is very deeply tinged, while no rock of this description exists in the neighbourhood. Even overlying the sandstone of the coal measures, where the occurrence of this mineral would be next to impossible, soil of a deep ferruginous aspect frequently presents itself. Moreover, in general this red soil forms merely a superficial stratum, often only a few inches in thickness, while the earth beneath, the obvious product of the decomposing gneiss or granite, has a white or gray colour, and scarcely any mixture of the tint which prevails on the surface. In all these cases we must look for the source of the red soil in the extensive region to the west, where nearly all the rocks give rise to it by decomposition, and we must regard it as having been transported to the spot on which it now rests, by some of those sweeping diluvial currents whose action is otherwise attested by evidences of a conclusive character.

The soils containing isinglass or mica, as well as those abounding in the clays derived from the decomposition of felspar, though in their natural state rather deficient in their productiveness, have generally been found to receive great benefit from the applications of lime and calcareous manures; and the district in question may reap great advantage from an extensive application of either. Its vicinity to the Eocene shell and greensand marls, as already indicated, is likely at some not remote day, to prove eminently beneficial to its agriculture, and it were to be wished that the farmers who are interested in its improvement, would promptly take advantage of such facilities of transportation as are likely soon to alter, for the purpose of availing themselves of the resources which nature has placed so completely within their reach.

In the neighbourhood of rocks where the felspar is comparatively abundant, the disintegrating process gives rise to a clay of a pure white colour, and almost impalpable texture. This is the *Kaolin*

of the Chinese, one of the essential ingredients in the composition of Porcelain. Numerous rich deposites of it are to be found in this portion of the state. In Goochland, an extensive bed of this earth has lately been discovered on the estate of Mr. Triplett. Its colour is a dull white. Between the fingers it has the smoothness of the finest flour, and with the exception of a few scattered grains of silex, the whole mass is a perfectly impalpable powder.

By a careful analysis of some of this earth, I find its composition to be as follows: In 20 grains,

Silica,	10.76
Alumina,	6.00
Water,	2.90
Loss,	.34
	20.00

In numerous places in Goochland, Cumberland, Buckingham, and other counties similarly situated, the Porcelain earth occurs in extensive beds, and in many cases in as available a condition as above described. This fact, taken in connexion with the known existence of felspar in the same region, points to the probable introduction at no distant day, of an important branch of manufacture in the state—I allude to the fabrication of the finer description of China or Porcelain, in which such excellence has already been attained by the employment of similar materials in Pennsylvania.

The region on the western borders of that which we have been describing, is marked by the occurrence of talcose and argillaceous slates, micaceous and garnet slates, chlorite slates, steaschist, various modified rocks, and numerous veins of auriferous quartz. The precise nature of many of the rocks occurring in this, which for the sake of distinction, may be called the gold region, cannot be determined without close and persevering attention.

OF THE AURIFEROUS ROCKS.

A general examination of this district suggests a variety of problems of a scientific as well as practical nature, which it would be premature at this time to attempt to resolve. The number and extent of the quartz veins is one of the most interesting as well as im-

portant features in the geology of this region, and it is greatly to be desired that minute observation be directed to the tracing of these veins through the state as far as practicable; to the determination of the general value of each vein now wrought, as well as the study of the efficacy of the various processes adopted for the purpose of separating the gold from the materials with which it is intermixed. There can be no doubt, that with the means now most commonly in use, a large proportion of the precious metal is lost and thrown out with the gravel from which only the larger masses of the gold have been separated. At one of the mines visited during the reconnoisance, the sand and gravel, after having been twice subjected to the usual process of washing, was found sufficiently productive to yield five dollars a day to each of the two persons who were washing it a third time. In some of the mines, more scientific and effectual means, both of conducting the mining operations and the subsequent process for separating the gold, have been introduced, and when these improvements shall have become more generally known, we may hope for much more profitable returns than in many instances have been hitherto obtained. The amazing richness of many of these veins, has attracted enterprise to this branch of mining to such an extent, that the exploration of the most promising auriferous veins, has of late been very actively and successfully pursued.

In Spottsylvania and the adjacent counties, Orange, Louisa, Fluvanna and Buckingham, numerous veins have been wrought for some time; from many of which rich returns have been procured, and under improved modes of operation a still larger profit may be expected. Any detailed account of the various workings now in progress would be inappropriate in the present report, even if the state of our knowledge were such as to warrant statements of a positive nature. Some account of the structure, position and contents of the veins may be introduced as generally applicable to the whole.

The material of the veins is a variegated quartz, sometimes translucent, at others opaque. It is generally of a cellular structure, fractures without much difficulty, and in many instances contains a considerable proportion of water, dispersed through its substance. Its surface, recently exposed, displays a variety of tints of brown, purple and yellow, of such peculiar aspect as to resemble a thin lacquer spread unequally over the rock. The cavities are often filled with a bright yellow ochre, or hydrated per oxide of iron, which generally

contains gold in a state of minute division. Sulphuret of iron, (Pyrites,) is another accompanying mineral, which in many mines occurs in considerable quantities. At Morton's mine, (Buckingham,) it is peculiarly abundant, and there, as in other places, generally contains a portion of combined gold. In the Union mine, near the Rappahannock, some of the auriferous veins consist largely of the Pyrites, which here contains so much of the precious metal as to render the extraction of it an object of profit. This Pyrites, in all probability, was at some former period, more generally diffused throughout all the auriferous veins, and by its decomposition, gave rise to the per oxide of iron, with which the quartz is always more or less imbued, while the gold existing in it was deposited in the cells and fissures of the quartz. *Silver* is occasionally found in connexion with the gold, and the sulphurets of copper and lead have been discovered in a few instances in the auriferous rock.

The rocks forming the boundaries of the auriferous veins, vary very much in different localities. Talcose slate, chlorite slate, and a variety of these, abounding in garnets, are the most usual. They are commonly of a soft texture, yielding readily to the blast, and even to the pick or spade sometimes. Instances occur, however, in which the walls of the vein are of such hardness as to greatly increase the expense and difficulty of procuring the ore. Of this a striking example is exhibited in Morton's mine, where the rock is removed with difficulty even by the blasting process, while at Booker's and some other mines, its texture is so rotten that it rather presents the appearance of earth than rock. Veins like the latter, under favourable circumstances, would give rise to what are technically called *deposite mines*, in other words, collections of clay and sand and gravel, enclosing a portion of gold, all which materials have been removed by the action of torrents or streams from their original position in the vein, to some adjacent ravine or hollow, in which they have been quietly deposited. The rocks adjacent to the quartz are often auriferous, and in some instances have been found as productive as the quartz itself. Of this, several striking instances occur in the mines of Buckingham; and I believe that in many other localities the same condition would be found to exist.

It has already been stated that nearly all the rocks of this region dip steeply to the east, and it is found that the auriferous quartz veins conform in the main to the inclination of the enclosing strata. The quartz is not, however, to be regarded as an interstratified por-

tion of the series, which would imply its contemporaneous origin with the strata.

The form and position of the veins is rarely such as to justify this view. Instead of lying in uniform thickness between the walls of the adjacent rock, and with surfaces of slight irregularity, we find the auriferous veins in most cases very irregular in their forms, at one point having a thickness of several feet, at another very near to the former, contracting so as only to measure a few inches across. Again, in many cases the vein divides, and the separate portions afterwards unite or send off other branches.

The bounding surfaces too, instead of being nearly uniform, as in the strata of the neighbouring rocks, are rough and broken, sending off numerous small veins of quartz into the enclosing strata.

In Morton's mines, the width varies from seven feet to five or six inches. In Booker's the vein forks, thins, and as frequently widens. At the Union mines on the Rappahannock, the breadth varies in some cases from six inches to nearly three feet.

In fact, from the dimensions of the vein at any assumed point, no certain inference can be drawn with regard to its extent at other and remote positions. This irregular structure, while it diminishes confidence in the constancy of a large and fertile vein, at the same time furnishes grounds for continuing the examination and prosecution of one, which by its contraction has become of little or no value, as an enlargement at a small depth beneath, may reveal an abundance of productive rock.

Another fact of some practical importance, and one which, together with those above stated, has a direct bearing upon the question of the origin of the auriferous veins, is this, that although in the main, the dip and direction of the vein conforms with those of the enclosing strata, the correspondence is far from being exact, and in many instances, while the inclination of the neighbouring strata remains unchanged, that of the vein undergoes very striking alteration. At Morton's mine, already referred to, the dip near the surface is about 20°, while at some depth beneath it becomes 45°; and similar instances of variation might be adduced by reference to other localities.

It would thus appear, that these numerous veins of quartz are not to be regarded as deposites coeval with the regularly stratified rocks among which they are found, since in that case their position and structure would exhibit a like degree of uniformity, but as matter

which, subsequent to the production of the neighbouring rocks, was forcibly injected between them by igneous agencies from beneath, rising in the directions of least resistance, and, therefore, generally, though by no means uniformly, following the places of stratification of the rocks through which they passed. Instead, therefore, of considering them as beds like the adjoining strata, as some writers have done, we would incline to class them among *veins of injection*, of which numerous instances occur in other parts of the globe. We are the more persuaded of the correctness of this view of their origin, from the consideration that throughout all the region in which the quartz veins are found, very peculiar modifications in the structure and composition of the surrounding rocks are invariably to be observed—modifications for which no adequate cause can be found in the other igneous rocks which occasionally occur. In the Blue Ridge, the South-west mountain, and in numerous other lines, it may always be remarked, that wherever the modified rocks occur, indicating an igneous action, more or less intense, which has wrought a change in their structure, and induced new arrangements of the ingredients of the rocks, heavy veins of quartz are sure to lie in their immediate vicinity; while through the body of the rocks themselves, countless minute veins of the same material are seen diverging from the principal mass, and imparting various metamorphic characters to the substances with which they are in contact.

Besides the auriferous veins of the region in which gold occurs, there exist many other veins of quartz agreeing with those which have been found productive in nearly all particulars, save that of containing a valuable proportion of the precious metal. It is highly probable that none of these veins are entirely destitute of gold, and in many instances no doubt the prosecution of the vein would lead to the discovery at other points of it, of an ore sufficiently rich to reward the labour of the extraction. Indeed, it must be looked upon as probable, that the auriferous character, more or less, pervades the quartz veins generally, even as far as their western limit in the Blue Ridge. The striking similarity in the character of them all, and the obvious *contemporaneousness of their origin*, would seem to give great plausibility to this opinion; and if we are to credit the statements of the discovery of gold in the western part of Albemarle, and at one or two other points equally remote from the gold region, as usually defined, we can no longer doubt the propriety of regarding the Blue Ridge as the proper western boundary of the auriferous

rocks. A careful investigation of the numerous large quartz veins ranging along the valley between the South-west mountain and Blue Ridge, becomes in this point of view a matter of great importance; and should the auriferous character be found pervading these veins, as is not improbably the fact, the extent and value of the gold region of the state will scarcely have a parallel upon the globe.

OF THE MICACEOUS AND GARNET SLATES, SILICIOUS SLATE, WHETSTONE BEDS, ROOFING SLATE, STEASCHIST, IRON ORE, &C. OF THE REGION WEST OF THE GNEISS.

In pursuing the line indicated in the section, after leaving the gneiss and hornblende slate, which extend some distance above Columbia on both sides of the James river, the rocks met with are chiefly various kinds of slates and schists, penetrated occasionally by the veins of auriferous quartz already described, and furnishing materials for building and other uses. Analogous beds are also met with in the regions north-east and south-west of that here referred to—ranging through the state in a belt comprehending what is usually termed the gold region, and bounded on its western side by the narrow belt of limestone lying east of the base of the South-west mountain. The descriptions about to be given of these various rocks and other materials, though founded upon an examination of them as they occur in Buckingham, Fluvanna, Louisa, and one or two other counties in the range, will obviously be applicable, with some modifications, to the corresponding beds occurring in other portions of the same belt.

MICACEOUS GARNET SLATE, OR BIRDSEYE MAPLE SLATE.

After leaving the gneiss and hornblende slate a little below Bremo, we come upon heavy vertical beds of a *micaceous slate*, in which are multitudes of half developed garnets, and sometimes crystals of cubical pyrites—giving to the surface of the rock the appearance of numerous knots, around which the fibres of the stone are beautifully curved, so as closely to resemble the shading of the birdseye maple; and hence, in the absence of any specific designation, the one above used may be considered as appropriate at least for ordinary purposes. This rock has the lustre and colour of plumbago, and evidently contains much mica. It possesses considerable hardness, and

may be separated in the quarry in large regular masses—and hence for slabs, pavements, and general building use, may be advantageously employed. At the Buckingham iron works, it has been used in the furnace stack, and has been found to answer well.

The *silicious micaceous slate* occurs a little west of the former, and has a sensible dip to the east, though almost vertical. This rock is of a light yellowish brown colour, contains a small proportion of mica, some felspar, and a large amount of silex, apparently in grains; and in fact, at first view, presents the aspect of some sandstones, though probably more nearly allied to the mica slates than any other known rocks. It may be quarried out in long rectangular prisms, with surfaces nearly as smooth as if formed by the chisel, and from its hardness and durability under exposure, is to be looked upon as a valuable rock. When intensely heated, it becomes glazed on the surface, and is used for the floor of the iron furnace at New Canton.

Associated with these beds, is one containing crystallized garnets in great numbers, and sometimes of exceeding beauty. This rock often contains much chlorite, and presents a general greenish aspect. Large quantities of it have been quarried in building the dam at New Canton, and a portion peculiarly abundant in the garnets, has recently been introduced in the furnace as an auxiliary flux. The large proportion of lime contained in the garnets fitting the rock peculiarly for this purpose, while at the same time it yields a considerable amount of iron.

The *whetstone* beds which occur among the silicious and other slates, also furnish a material of high value. The texture of this stone is exceedingly close and fine; it possesses a proper degree of hardness and great permanency under atmospheric exposure. Its apparently fibrous structure, and the long shape of the masses which are separated in the quarry, give it the appearance of a log of wood, partially decayed. The trial of its qualities as a whetstone, made in Fluvanna, Rockbridge, and the neighbouring counties, amply demonstrate its excellence for this purpose, and in some instances, experienced mechanics have evinced their sense of its superior value by laying aside the Turkey oilstone, and substituting this in its place.

One of the most interesting and valuable of the slaty rocks of this region, is the *roofing slate* which occurs in a thick bed west of the strata which have just been described. This makes its appearance

on both sides of the James river, dipping east at an angle of about 80° with the horizon. In Buckingham, the bed is largely exposed in the neighbourhood of New Canton on Slate river, and the quarry at present wrought by the enterprising owner, Mr. Sims, yields a material which will bear comparison with the better qualities of the imported roofing slate. In texture, density and capacity of resisting atmospheric agents, it can scarcely be excelled by a similar material in any part of the world. This quarry was first opened to procure slate for roofing the capitol; and notwithstanding it has been thus long known, and its value established, but little further use has been made of it, until the activity of the present proprietor has again brought it into notice. The buildings of the University will soon be furnished with a complete covering of slate from this quarry. The bed of slate wrought by Mr. Sims, has an average breadth of sixty yards. The rock splits with great regularity, presenting a smooth surface, and having such strength and flexibility as to admit of being separated by iron wedges into sheets of 100 square feet, and not more than an inch in thickness. There are many other places in the neighbourhood, from which slate of the same kind may be procured, and several small quarries have been opened. Increased facility and cheapness in transporting this valuable article to Richmond and the seaboard, will, no doubt, at some early day bring it into extensive use in our principal towns in that direction, and will render the quarrying and preparation of it a profitable business. During the last year, Mr. Sims brought into a state for the market, six hundred squares of this slate, at twelve dollars per square; and this, with but few hands and very imperfect arrangements.

The *steaschist* or *soapstone* which occurs west of the slate, and may be seen near the mouth of Hardware river, both in Fluvanna and Buckingham, though not as valuable as other beds of a somewhat similar description, to be hereafter described, is nevertheless capable of being very usefully employed. In hearths, jambs and other parts about the chimney, it is found to possess useful qualities, and its texture is such as not only to render it easy of separation in the quarry, but also to make it readily wrought under the chisel. At Bremo it has already been brought into use.

Several veins or beds of *iron ore* exist in Buckingham in the region of the gold veins and slates, and ore of similar description makes its appearance in Fluvanna, Louisa, &c. In the former

county indications of this deposite have been distinctly traced throughout a line of seven miles, and the proprietors of the furnace at New Canton have assured themselves of its continuity for two miles. West of the principal vein is another at the distance of 100 yards: a vein of friable slate dipping east occupying the interval. In the first or principal bed a continuous mass of ore has been uncovered, whose length is about 60 feet, and average breadth 15. As yet no certain opinion exists as to the depth to which it reaches below the surface. This ore is generally embedded in a brownish-yellow ferruginous clay, and fragments lie scattered over the surface in the neighbourhood of the bed. Through a long but narrow belt in Louisa, Fluvanna and Buckingham, and in fact throughout the whole length of the gold region, so called, these surface indications may be traced. The ore is a *hematite*, in irregular masses, sometimes cellular and frequently mammillary. The cells often contain acicular white crystals of great lustre. The colour of the ore varies from a yellowish to a blackish-brown. Its hardness in different localities also differs, and in the immense mass above described, is such as to render blasting necessary. There is some difference as to the proportion of oxide of iron contained in the ore from the two veins near New Canton, and a mixture of both varieties of ore has been advantageously used in the furnace now in successful operation. As early as the revolutionary war iron was manufactured from the Buckingham ore, but until recently this valuable resource has been almost entirely neglected. The limestone on the western edge of the county furnishes the flux employed in the smelting of this ore, which, under the superintendence of Mr. Dean of New Canton, is now conducted on a scale of such extent as to give a weekly product of between 30 and 40 tons of pig metal, much of which is of a superior quality. Ore of precisely the same description is found likewise in the gold region above Fredericksburg, and as in the present instance, in the vicinity of the garnet slate. From the curious association of this ore with the auriferous rocks, it might be expected that in the operations of the furnace a portion of the precious metal would occasionally appear, and accordingly it has been discovered in fine specks in the cinder of the Buckingham works. Magnetic iron ore of a very valuable quality occurs at the base of Willis' mountain in Buckingham, and is found at several other places in corresponding positions.

OF THE LIMESTONE AND MARBLE EAST OF THE SOUTH-WEST AND GREEN MOUNTAINS.

This belt of rock, represented on the profile as it occurs on the Mechunk creek and in several other places, may be traced with but little interruption through several counties lying in the range there indicated. In proceeding south it appears to become broader, and to be subdivided into several ledges, presenting various aspects in different localities. Wherever examined it has been observed to have an eastern dip, in some places steep, in others gentle. In Albemarle county and at Warminster, its structure approaches to slaty, and its general colour is bluish-gray, frequently veined with white crystallized calcareous spar. On the Mechunk, it lies on slate often of a talcose nature, and its position is such as to render the labour of quarrying comparatively small. At Warminster it is also associated with a talcose schist and a white silicious rock of fine grain and considerable hardness, which has been often mistaken for marble. Along the banks of the James river, from this point to the neighbourhood of Lynchburg, cliffs of the limestone from time to time are seen, sometimes presenting enormous masses of the rock, immediately on the water's edge. The breadth of the belt exposed in this direction is obviously much greater than farther north, and the character of the rock in some localities is such as to render it of the highest value. Near the mouth of Tye river and on the Rockfish, a true marble is found of beautiful whiteness, and of a texture which renders it susceptible of a fine polish, as well as of being readily wrought by the chisel. A few miles from Lynchburg, in Campbell county, a good marble is likewise found, and limestone is abundant in the same neighbourhood. A white and very ponderous rock occurs in contact with the calcareous stratum. This is sulphate of baryta, which from its texture and colour has by some been supposed to be marble. Farther south these beds of limestone of various qualities are known to occur, but have as yet been little examined. The probability is that they are continued throughout the state in the same general line, perhaps spreading out in approaching the borders of North Carolina. In Bedford county, at a point considerably west of the general direction of this belt, marble is said to exist, but no specimen has been procured in the reconnoissance. Minute investigation of the region indicated by the localities above mentioned, and extending entirely across the state, would in

all likelihood be fraught with valuable results. Leaving out of view the marbles to which we have already referred, the beds of limestone existing in this district of the state furnish a resource whose value to the agriculture of a wide tract of country it is beyond our power to calculate. Every bed of limestone developed in such an examination ought to become a source of agricultural improvement to an extensive neighbourhood; and were our farmers once properly impressed with the value of calcareous matter as a manure, especially on the soils of the region now in question, an earnest zeal in the discovery and use of these resources would quickly become general, and an important district of the state would be rescued from unprofitable and disheartening cultivation. Lying adjacent to the slaty and micaceous soils east of the South-west mountain and its prolongation, this belt of limestone furnishes the very material by which under judicious management they may be redeemed from comparative sterility. In Orange, Albemarle, Louisa, Fluvanna, Buckingham, &c., the application of lime procured from this source might with proper arrangements, and the increased facilities which are likely to be afforded to transportation, be made to effect an entire revolution in the agriculture of the country—and even in Goochland, and other counties comparatively remote, similar benefits might be secured at a small additional expense. It is perhaps not generally understood that the slaty and micaceous (or isinglass) soils, such as prevail in the districts referred to, are known to be peculiarly susceptible of improvement from judicious liming. The experience of farmers in Maryland and Pennsylvania has amply shown that this is the case—in those states soils thus characterized are limed to a large extent, and always with the most decided benefit. Experiments made in Albemarle and other places with the lime procured from the limestone beds of which we are now speaking, have demonstrated its value upon the slaty soils in the vicinity, and nothing is wanted to diffuse these benefits extensively through the surrounding country, but a just appreciation of the utility of liming, the introduction of economical and efficient modes of burning the limestone, and the selection of such quarries as from the nature of the rock are calculated to yield a product containing the largest quantity of lime.

A mistaken impression has prevailed, that this limestone always yields a comparatively poor lime; and to this may in part be as-

cribed the little use which has heretofore been made of it, either in agriculture or building.

It will be seen by the following statement of results of analysis, that the amount of carbonate of lime present in these limestones, is in some cases large, and that in no instance can the lime be regarded as a poor one. I have annexed a column, showing the proportion of lime corresponding to 100 parts of the limestone:

		Carb. Lime.	*Lime.*
100 of blue slaty limestone—	Warminster,	81.4	45.5
100 of blue with white veins,	do.	88.4	49.5
100 of blue slaty,	Mechunk,	83.2	46.6

The extensive exposures of limestone on both sides of the James river, existing in the neighbourhood of Lynchburg, New Market and Warminster, from their very favourable position as regards the facilities of conveyance, are calculated to become peculiarly valuable. Indeed, no position could be found in the state in which lime-burning could be conducted on a larger and more profitable scale. By the introduction of the perpetual kilns now generally used in the extensive lime-burning establishments of the eastern states, much fuel would be saved, and all the lime which the rock is capable of furnishing, would be obtained; while, by the plan usually pursued, much wood is wasted, and the limestone, particularly of the slaty kind, is but imperfectly calcined. These improvements once adopted, and the better kinds of limestone selected for the kiln, there appears to be no reason why this favoured region may not be able to furnish our eastern towns with lime more cheaply than it can be imported from abroad, at the same time that it is imparting to the surrounding country the benefits of an improved productiveness, and a wiser system of cultivation.

To what has already been said concerning the marble of this region, nothing positive can be added without further investigation. It may, however, be remarked, that from the specimens already seen, particularly the white marble from Tye river, there is reason to hope that this, likewise, may become an object of much value to the district in which it occurs. The Tye river marble, and one or more analogous veins, have all the characters of a statuary marble of fine quality, and should not some peculiarity, as yet unperceived, prevent their application to the purposes of the sculptor, they will no doubt be looked upon as very valuable possessions.

OF THE ROCKS, ORES, SOIL, &c. OF THE REGION WEST OF THE LIMESTONE, AS FAR AS THE WESTERN FLANK OF THE BLUE RIDGE.

This extensive district of the state comprises a great variety of slates, sandstones, schists and other rocks, almost uniformly dipping east, and in general at a very steep angle. Quartz veins are frequently met with, some of which are believed to be auriferous, though as yet, no profitable mine of the precious metal has been opened in them. Beds of trap occasionally occur, the material of which, from its dark colour and extreme hardness, is usually known by the name of *iron rock*. In some portions of the district, hornblende enters largely into the composition of many of the rocks, while in others, talc and chlorite appear chiefly to abound. But it is important to remark, that amid all the diversities in the mineral character of the strata, a very general conformability of dip may be observed. Looking merely to the mineralogical constitution of the rocks in many localities, an impression of the undoubted primary character of this district would naturally arise. But when a more general exploration of the region discloses the existence of extensive beds of genuine sandstone, and conglomerate rocks frequently in contact with the former, and having the same uniform inclination, we are unable any longer to maintain this view. This opinion, however, would be found incompatible with the results of a more extensive observation of the rocks, of which this region principally consists. It would then be found, that a large portion of its area is occupied by beds of genuine sandstone and conglomerate rocks, and that the chief part of those strata, which at first view might be regarded as crystalline and primary in character, are in reality modified forms of sandstones and conglomerates, which, through intense igneous action, have been made to assume appearances more or less closely resembling those of rocks of the latter description, thus disguising, almost entirely in some cases, the original sedimentary structure by which they would be characterised as not appertaining to a primary formation. It is the existence of this curious class of rocks in many parts of the region in question, as well as the occurrence of occasional beds in which no appearance of the sedimentary origin can be traced, which imparts to the minute geological investigation of this part of the state, so much of scientific

interest, and at the same time renders the task of such an examination laborious and difficult.

Whatever may be our view of the origin of the truly crystalline rocks which occasionally occur throughout this region, numerous sectional examinations, which have been made with the view of solving some of the difficulties connected with its geology, have combined in establishing this interesting conclusion, that by far the largest portion of its surface is occupied by rocks which do *not* belong to the primary system, while they have, at the same time, served to display the modifying effects of igneous agents, as manifested in the changed structure of many of these rocks, on a scale of wonderful variety and extent.

Early in the present report, allusion was made to the prevailing errors on the subject of the true geological character of this region, inclusive of the Blue Ridge; and enough has already been stated in regard to the structure of the region, to satisfy the enlightened geologist of the entire impropriety of the designation of primary which it has heretofore uniformly received. The further particulars about to be given relative to some of its rocks, chiefly those of economical value, will serve still more clearly to evince the inaccuracy which has hitherto prevailed with regard to the limits of the great geological subdivisions of the state, as well as to display the practically valuable results which are linked with an investigation which at first view appears to be purely scientific in its character.

The rocks of the South-west mountain and its prolongations, and of the country within a few miles on either side, will first be described, after which some account will be given of those lying more to the west, and in particular of some portions of the Blue Ridge.

Pursuing the line indicated in the profile, after leaving the bed of limestone, already referred to, we meet with slates and schists in some places of a micaceous and talcose, and in others of a silicious nature, and so friable as to be of but little use in building; comprising occasional beds of a denser texture, and more resembling roofing slate. This brings us to the greenish and dark blue argillaceous sandstone of which Carter's mountain, as well as much of the region on its eastern and western flanks, principally consists. Beds of gray and yellow sandstone occasionally present themselves among the darker rock, and these are uniformly of a coarser texture, and in many cases are rapidly decomposed by exposure to the air and weather. Quarries of the dark greenish and bluish rock have

been opened in many places, and furnish a material for building which can hardly be excelled either for strength or permanency under exposure. Much of this rock, however, is so hard as to prove difficult of separation in the quarry. This is remarkably the case with the green variety, which occurs very abundantly for a mile or two east of Meriwether's bridge on the Rivanna. This rock bears the strongest marks of intense igneous action in its flinty hardness, and in the large quantity of green epidote which has been developed throughout its structure. It is, moreover, always intersected by veins of quartz, so that it would be difficult to find a mass of considerable size, in which many of these veins would not be visible. It is further to be remarked, that always in the vicinity of these quartz veins, the rock is hardest, and displays the largest portion of the green colouring material. All these facts would seem clearly to point to the quartz, as having been directly concerned in the various modifications which the rock has obviously undergone. In further illustration of this view, it may be added, that often in the immediate neighbourhood of the veins of this material, asbestos, iron pyrites and other minerals occur, which are known to be thus developed in various rocks by veins of intensely heated matter injected into them in a state of fusion. At Meriwether's bridge and in many other localities along the range, the greenish-blue rock is studded with black and greenish spots, indicating an incipient crystallization, and clearly referable as the geologist would at once perceive, to the agency of which we have spoken. Here, as well as in all places where similar evidences of igneous action can be traced, the dip of the rock becomes confused in consequence of the occurrence of numerous cross joints, such as are often produced in stratified rocks by an action of this nature.

The gray and yellowish-red sandstone, occurring in beds sometimes of considerable breadth, and traversing the country in the general range of rocks to a considerable distance, are found in many places to furnish quarries of very valuable building material. Such of these beds as are intersected by frequent veins of quartz, are found to be by far the hardest and most valuable. In the same bed, examined at points some distance asunder, a great difference in the hardness and consequent value of the material, may frequently be observed. Thus, the bed which on the eastern flank of Peter's mountain, near Gordonsville, yields a building stone which comes from the quarry in long quadrangular blocks of great hardness and

durability, presents at the distance of several miles to the south a crumbling mass, whose value consists in its being useful as a substitute for sand, or furnishing a good material for the manufacture of fire bricks. It may, therefore, be found a guide *of some value* in the selection of rock for flags or building purposes, to choose such as, lying in the vicinity of a heavy vein of quartz, and intersected by smaller ones throughout its substance, is likely to possess the combined advantages of great hardness and durability, and a comparative facility in being quarried, in virtue of the cross joints by which it most generally and spontaneously divides itself.

In addition to the rocks here described as occurring particularly in the South-west mountain and its vicinity, various others are presented both to the south and north of the localities to which the profile may be considered as referring. Thus, in Orange and in Nelson and Amherst counties, as well as in the neighbourhood of Scottsville, in Albemarle, and interruptedly in many other places in the same general range, a very interesting rock is seen, consisting of fragments sometimes angular, sometimes more or less water-worn, cemented together by particles of sand, and occasionally a small admixture of carbonate of lime. This singular conglomerate has evidently been in part derived from the greenish-blue rock previously described, with which its larger pebbles or fragments are obviously identical—and in part from the sandstones and occasionally the limestones of this region. It is in fact the representative, in this portion of the state, of the Potomac marble, and some of it when polished would present a surface of equal variety and beauty. The occurrence of this rock, as here described, obviously marks an epoch of violent action, in which the neighbouring strata, of which it may be considered as embodying the ruins, were broken into fragments, and these subjected for some time to the rounding agency of water, at the bottom of which the coarser and the finer sediments were at length consolidated into rock. A curious fact, for the first time observed by my brother, Professor H. D. Rogers, would seem to show, that in the composition of the Potomac marble, fragments of limestone may be seen, referable to no nearer source than the great valley west of the Blue Ridge. In some of the columns in the senate chamber at Washington, which by their beautiful polish enable the observer as it were to look into many of the rocky fragments of which they are composed, he detected distinct impressions

of Encrini, a fossil remain abounding in the bed of limestone near the western flank of the Blue Ridge, and for which we might in vain look in the limestone previously described as skirting the eastern flank of the South-west mountain. This curious discovery will at once indicate the extent of the violent agencies preceding the formation of this rock, and of the conglomerate which we have regarded as its equivalent.

In the same region likewise, beds of genuine red sandstone occur, sometimes of a fine and sometimes of a very coarse grain. This and a variety of red slate are the chief rocks to be met with between Warminster and the Folly. Similar beds are to be seen in many places in Orange and other counties in corresponding positions. In Amherst, near the Stonewall mills, strata of coarse conglomerate occur, in which the pebbles have sometimes a diameter of half an inch.

Near Lynchburg, a very beautiful bluish-gray sandstone is largely quarried, and in the same neighbourhood very extensive exposures of various sedimentary rocks may be seen. In nearly all the localities which have been described, the dip of the rocks is east. At the latter place, however, a very superb exposure of a silicious and talcose schist is presented on the river bank immediately opposite the town, exhibiting the feature so strikingly seen among the sandstones of the North mountain—that of an arch or great bend in the strata, showing the eastern and western dips at its opposite extremities.

On the western declivity of the Green mountain, beds of steatitic rock occur, furnishing a soapstone which in all respects compares advantageously with that now generally in use. A quarry of this rock has been opened near the residence of Tucker Coles, Esq. from which slabs and jambs for fireplaces have been procured. The colour of the rock is a grayish and sometimes greenish-blue, with a somewhat marbled appearance. Its texture is fine, and with sufficient firmness for any purpose to which it may be applied. It is capable of being cut and planed with great facility. With the exception of some of the finer kinds quarried in Vermont, there is probably no soapstone used in this country which combines the valuable characteristics of this species of rock in a higher degree. The recent introduction of anthracite as a fuel in some of our cities, and the probability that ere long the semi-bituminous and anthracite coals of the western ridges of our valley will also be similarly ap-

plied, impart additional interest to the facts here stated, and render it highly probable that this rock will at no remote day be brought into extensive use. In the same neighbourhood are found sandstones and schists, all preserving the same general direction and dipping to the east.

Throughout the South-west mountain and its prolongations, but especially on the Buffaloe ridge, *micaceous and magnetic iron ore* occur. In the neighbourhood of Stonewall mills, and near the Buffaloe ridge spring, these ores are peculiarly abundant. They are also met with largely in the vicinity of the Folly. Hematite containing some manganese is seen also apparently in veins in a slaty rock at Reuben Carver's, near the above named mills, and has been supposed by some to be an ore of silver. The micaceous oxide is generally blended more or less intimately with the substance of a talcose and silicious schist, and appears to exist in beds of considerable breadth amid these rocks. Hitherto, little value appears to have been attached to the magnetic oxide or oxidulated iron ore which is thus abundant throughout this region; and yet, judging by the experience of other countries where this ore is smelted in great quantities, there can be but little doubt that under a judicious system of operating it might be found a highly valuable material for the manufacture of iron. In the highlands of New Jersey, so noted for the quality and amount of their forged as well as cast iron, an ore of precisely the same character is used, and the difficulties in smelting, which appear to have deterred our iron masters from its employment, are completely overcome.

In many places, within the belt of which we are now treating, beds of rock occur, containing green carbonate, sometimes associated with a little sulphuret of copper. At the Folly in Amherst, numerous openings may be seen from which the cupreous rock was formerly obtained. The amount of copper present in such of the specimens from this locality as have been examined, though considerable, is not such as promises any high degree of value in the mass. It is, however, to be remarked, that no positive opinion on this subject can be formed without much minute examination of all the places in which this rock exists, as well as a number of analyses to determine the proportion of copper which it contains. No distinct vein or bed of copper ore is indicated, but rather an impregnation of the talcose rock of the neighbourhood, more or less strongly with

Rocks of the Blue Ridge commencing at the western base at Turk's Gap.

1. A light gray moderately fine-grained sandstone, met with near the base of the gap, and extends up a third of the way to the top. Dip steep to the S. E.

2. A finer closer-grained rather bluish variety of the same, overlying the former.

3. A lead coloured argillaceous slate, slightly talcose, occupying another third of the western side of the mountain.

4. A dark-purplish gray and extremely close-textured indurated sandstone, bearing evident marks of igneous action. This bed is not thick.

5. A schistose gray sandstone, rather argillaceous, with minute specks of black sand, and little grains, the size of a pea of transparent amethystine quartz.

6. A greenish-gray chloritic looking schistose sandstone.

7. A fine-grained dark bluish-green argillaceous sandstone, full of incipient crystallization in small vitreous specks, the size of mustard seed. These specks are small amygdals, the exterior being a semi-transparent yellowish-green matter like quartz, the centre being black and granular.

8. An argillaceous sandstone like the former, but containing more crystalline specks, some of which are of an opaque pinkish-white.

9. Like the two former, the specks being better devolved, some of these green and transparent, others pinkish-white, looking like analcime.

10. A very coarse, extremely hard sandstone, round grains of semi-transparent quartz, in a coarse argillo-silicious paste, evidently much indurated.

11. A coarse-grained purple sandstone; the rounded gravel of pink or amethyst coloured quartz, united by a dark paste.

12. A gray purplish porphyritic looking conglomerate, of very heterogeneous composition, green, red, white, &c. some felspar, much quartz, and to appearance the matter of the green sandstones of the ridge.

13. A similar compound approaching to a brick red, angular

pebbles of felspar and rounded ones of quartz, &c. in a deep red paste. The four last specimens belong to the S. E. slope of the ridge.

14. A white, rather loose and coarse sandstone, the grains united chiefly by felspar.

15. A coarse sandstone, with rather angular pebbles of quartz and felspar scattered through a paste very similar to the mass of a greenish chloritic sandstone.

16. A very light lemon-green epidotic sandstone, with small specks of quartz and veins or patches of asbestos.

17. A very heterogeneous conglomerate, in aspect somewhat like the Potomac marble, and identical with the conglomerate before described as occurring in the vicinity of the S. W. mountain, &c. the larger pebbles identical with No. 6.

18. A compact, close-grained purplish-gray sandstone, greatly altered, having kernels of epidote, and quartz, and deep red blotches, making it look like heliotrope.

19. Similar to 7, but destitute of the specks.

20. At the eastern base of the ridge, slaty sandstones of a gray colour.

In presenting the above account of the series of rocks in this portion of the Blue Ridge, I do not wish it to be inferred, that precisely the same beds in the same order will everywhere be found. Observation has shown, that in different parts of the range, the rocks vary somewhat in their character, that while in some places the sandstones are greatly indurated, and filled with various minerals apparently developed by intense heat; in others, they are comparatively unaltered, though in all the localities yet visited, some of the beds exhibit great induration from this cause. We are, however, to take this descriptive list as representing the important peculiarities of the rocks of the Blue Ridge, and we have preferred thus describing them in some detail in the order in which they occur, to attempting to name them according to any supposed or fancied analogies they may bear to rocks, which are found in the old world. Such analogies are very vague, and in this as in many other instances in the geology of our country, are calculated to give permanency to error and check a proper spirit of investigation. In the true spirit of his science, the enlightened geologist has learned to distrust the generalizations which would always seek analogues to

the rocks of one side of the globe, in those of the other, and will, therefore, prefer a description of the object itself to any appellation to which, from its supposed resemblances, it might be thought entitled.

From the list above given, it will at once appear, that, there is no material difference between the rocks of the Blue Ridge and those of the South-west mountain and the intervening country, and that they seem in the main to be distinctly referable to a sedimentary origin.

From the above view of the general structure of the ridge, we may derive a suggestion of some importance in connexion with plans of internal improvement projected in the state, which is, that the dense and impracticable character of many of the rocks above described,—for instance, those from six to twelve,—forbids any attempt at tunnelling the mountain, at least in those places which have been examined, and evinces the necessity, whenever such a plan shall be proposed in reference to other parts of the ridge, of first ascertaining whether it does not there also include near its axis materials equally unfavourable to operations of this kind.

The *soils* of the region from the Blue Ridge, east as far as the limestone, are in many places of a deep red or chocolate colour, while in others they present either a grayish or yellowish hue. Those of the former kind are usually regarded as most fertile, and chiefly give value to the lands of Albemarle, Amherst, and other counties in this part of the state. In accounting for these striking peculiarities of colour and agricultural properties of the soils in question, it has been usual to regard them as resulting from the hornblende, frequently met with in the rocks of this region, which by its iron would give colour, and by its lime impart fertility, to the land. There is, however, but a small portion of this deeply coloured soil traceable to a decomposing rock of the description mentioned, and by far the largest part of the land thus tinged had been produced by the disintegration of the dark greenish-blue sandstone, such as occurs so abundantly in the South-west mountain. Much of the richest and darkest red soil of Amherst and Albemarle has no hornblende in its neighbourhood, while beneath and mingled with the soil, fragments of the sandstone above referred to, may be seen in all the gradations of condition, from the hard greenish rock recently separated from the mass, to the crumbling half-earthy and deeply

reddened lump, ready to be reduced by the next winter's frost into productive soil. By analysis recently made, I find that both the greenish sandstone and the resulting soil, contain a sensible quantity, sometimes two per cent. of lime. Should this be found by further research to be an invariable ingredient of these valuable red soils, we might, perhaps, be authorised in ascribing their productive character, at least in part, to its presence; and we would to a certain extent be enabled to compare these soils with one another in agricultural value, by chemically examining them for lime.

Portions of the red soil in Nelson and Amherst, arising from the decomposition of a red sandstone and conglomerate before described, contain lime in a still more considerable proportion. The rocks from which they are procured, in some instances, present upwards of six per cent. of carbonate of lime. A specimen recently examined, yielded me in one hundred grains, precisely 6.75 grains of this substance.

OF THE VALLEY OF VIRGINIA.

The sectional line crossing this region, to which the profile refers, commences at a distance of two or three miles from the western base of the Blue Ridge, this being the position at which the rocks of the valley first become apparent. Of the character of the beds comprised in this interval, we have no data enabling us to speak with certainty, inasmuch as the fragments of sandstone derived from the broken strata of that range, piled upon the subjacent beds of the valley, entirely conceal them from observation. At other points along the eastern edge of the valley, the interval thus hidden from examination is not so wide, but in no place hitherto observed have the rocks of the valley and those of the Blue Ridge been seen in contact. This, as yet, undetermined ground, is therefore represented on the profile by a blank, at the western boundary of which the valley rocks, where first observed, are represented as commencing. Future observations throughout this curious district are indispensable to an understanding of the true relation existing between the formations bounding it on either side, and will accordingly present subjects of geological, and even of practical interest in the prosecution of more detailed research.

As the profile indicates, beds of slate and limestone, in alternate

order and dipping almost uniformly to the east, occupy nearly all the space west from this to the commencement of the sandstones of the ridges subordinate to the North mountain. Layers of a very silicious limestone, and bands of sandstone, occasionally occur. Between Harper's Ferry and Winchester, two alternations of the slate and limestone may be observed; the most eastern bed, composed of slate, dipping east at an angle of 30° into the valley of the Shenandoah, succeeded by a broad range of limestone of a dark blue aspect, and but little veined, dipping in the same direction, next to which is another bed of slate followed by one of limestone, both dipping as before.

Approaching the northern extremity of the Massanutten mountain, the belt of limestone presents interesting peculiarities, some of which may with great probability be referred to the proximity of that lofty range. It is here traversed by large veins of calcareous spar, in general running across the direction of the edges at a considerable angle, and it is thrown off from the flank of the mountain with a reversed or western dip. The veined condition of the rock distinctly pointing to a period during which it was subjected to violent actions, cleaving it into countless fissures, subsequently filled by infiltration with the pure material of the rock, taken in connexion with its inverted dip along the mountain flank, gives great probability to the idea that the upheave of this range took place subsequently to the formation of the rocks of the valley, and that thus the fissured structure and changed direction of the adjacent rocks, were merely consequences of the elevation of this enormous mass. In connexion with this curious point of inquiry, the investigation of the materials and structure prevailing in the Massanutten mountain, cannot fail to prove interesting to the geology of the state. Such an examination, moreover, promises more than any other to reveal the geological relations of the valley with the regions bounding it on either side, and thus to solve some of the most curious problems with which the student of our geology at present cannot fail to be embarrassed.

In the valleys of this mountain slates and limestones occur, and rumour intimates that *coal* even has been found. Beds of a coarse conglomerate of very peculiar structure, constitute an important portion of its mass, and furnish the material of mill-stones, now much in use. Limestone is said to occur on the summit of the Peaked

mountain, a part of the Massanutten, and it is not improbably the fact.

Should coal ever be discovered in this region, it will probably be *anthracite;* and certainly the character of the rocks of the Massanutten, so far as they have yet been examined, is not *adverse*, if it be not favourable, to the opinion that the search for this mineral might be attended with success.

In passing some distance south and west of Strasburg, the strata resume their former eastern dip, having here apparently been too remote from the mountain, to experience much violent dislocation or change of direction when it arose.

In the counties of Rockingham, Augusta and Rockbridge, limestone and slates, alternate as before; the former in some places passing into veined varieties, and occasionally presenting bands and beds of *marble* of a good quality. A roll in the strata, or some change and irregularity in the dip, will usually be found to attend the veined or marbled varieties of the limestone, and may be looked upon as a useful guide in the search for quarries of the ornamental rock. A bed or beds of hydraulic limestone, runs along the valley not far from its eastern side, to an extent not yet determined. In the neighbourhood of Shepherdstown, this rock has been quarried, and found highly valuable in the formation of water cement. A similar limestone appears on the North river, about nine miles from the Balcony falls, and at some intermediate points, but as yet no analysis has been made of the rocks from these localities, and but imperfect trials have been made of the lime obtained from them. It would appear that a limestone of analogous character is found also in Botetourt county, and even further south.

An analysis of the hydraulic limestone from the neighbourhood of Shepherdstown, shows it to contain nearly a third its weight of alumina, while the common limestone of the vicinity, and indeed of the Valley generally, contains but a small proportion of this earth. A mere analysis, however, is not always sufficient to determine the value of the material, for the purposes of a cement; and should, therefore, be accompanied with direct trials calculated to test its qualities in this respect. Attention is only beginning to be directed to this subject, which is one to which, from the character of some of our great works of improvement, a minute geological and chemical investigation might be very beneficially directed.

It is curious to remark, that in Pennsylvania and New Jersey, limestone of this description occurs in precisely the same relation to the other rocks as in the region we are now describing; and from its well known and fairly tested value, as employed in those states, we may look with confidence to the early discovery of valuable beds of it in numerous parts of the corresponding region in Virginia. Fortunately for its use too, the anthracite of the North mountain is of that description of coal which has been found by far the most suitable fuel in preparing it for a cement.

The existence of *fossiliferous bands*, in some of the limestones of the valley, is an interesting geological fact, of which no notice appears hitherto to have been taken by those who have professed to explore the country with scientific objects. Near Strasburg, on Cedar Creek, and other points around, the rock displays great numbers of impressions, of encrini, &c. and some trilobites. At Mount Meridian mills, in Rockingham, organic limestone likewise occurs, and what is most remarkable as having hitherto escaped attention, the limestone of Weyer's cave and the vicinity occasionally exhibits similar impressions of a very interesting and peculiar character. Farther west, in the neighbourhood of Mossy creek, fossils occur in a more silicious variety of limestone, and I have in my possession a fine specimen of fucus from this locality. Such bands of fossiliferous rock seem to be of more frequent occurrence farther south, and are quite common in Botetourt and Montgomery counties.

The importance of the valley *limestones*, as furnishing a powerful lime for agricultural and various other uses, cannot be too highly appreciated; indeed, it is rather matter for surprise, that the agriculture of this region has hitherto been suffered to reap so little general benefit from this great source of improvement completely within its reach. As yet the application of lime to the lands in this part of the state is in a great degree restricted to particular neighbourhoods, while (in many extensive districts) through the want of experience, and of knowledge respecting its employment elsewhere, the efficacy of lime as a manure, is regarded with a degree of doubt sometimes amounting to entire disbelief. An impression that the soils of this country are already sufficiently impregnated with calcareous matter, in consequence of the proximity of the limestone rock which occasionally rises to the surface in the fields, seems more than any

other circumstance, to have led to the erroneous notion that lime could be of no benefit to the soil. It must therefore be regarded as a fact likely to affect the opinions and practice of persons entertaining these views, that in a great many cases, the soils of the valley contain little or no calcareous matter, even when taken from the immediate vicinity of a limestone rock—a fact which has also been observed by my brother and myself, in regard to many of the soils in the corresponding region in Pennsylvania and New Jersey. In the valley of the former state, lime has long been in extensive use, and is well known to have been the means of imparting rich productiveness to many wide districts in the limestone country which were formerly regarded as of little value, while in the small belt of corresponding character in New Jersey, a soil of almost sterile worthlessness has by the same means been imbued with an extraordinary degree of fertility. Experience thus ample and satisfactory, under circumstances which can leave no doubt as to the applicability of the results to the valley of our own state, will, it may be confidently hoped, impress our farmers in that region universally with the importance of availing themselves of the invaluable resource which is everywhere spread around them, and of thus removing the imputation of indifference to improved modes of agriculture, which the active enterprise of other regions has already proved to be of great permanent advantage.

The value of the limestones of our valley, with a view to this most important of all their applications, may be judged of by the results of several analyses recently made, from which it appears, that in most cases, the carb. of lime exceeds 80 per cent., and in some is largely over 90 per cent. of the whole mass. A series of analyses, giving the composition of all the varieties of the rock in numerous localities in each county through the valley, would subserve one of the important interests of this region, by enabling the farmers to infer what ought to be the proportion of pure lime present in the product of the kiln in each locality.

Another valuable material hitherto neglected in this region, is the *travertine* or deposite marl which exists in some places in large quantities. In Jefferson and Frederick, this chalky deposite forms beds of considerable thickness, mingled with but little extraneous matter. In Rockbridge, nearly all the streams that empty into the South river, flow over a material of the same nature; and in fact

no extensive district of the valley will be found wanting in this deposite. It is in truth a precipitation of the calcareous matter from the limestone waters, which are universal throughout this region, and must therefore be looked for as occurring in most neighbourhoods where springs thus impregnated are of general occurrence. Now, it is important to be known, that from this substance a lime of very superior quality may be made, and that judging by the value attached in the market to that from the travertine of Caledonia in New York, the burning of this material in some of our localities might be attended with very considerable profit; at all events its utility in agriculture added to the facility with which in some places the deposite may be obtained, (no quarrying being necessary to separate it from the mass,) would render it an advantageous substitute for the limestone of the same neighbourhood. Moreover, it should be remembered, that in the more friable or powdery state in which much of it is found, it may, as in Europe, be very beneficially applied as a marl without being burnt. The immense improvement which eastern Virginia has derived and is now receiving from the calcareous manures, must render any illustration of the effects of this substance altogether superfluous, when it is understood that in composition it cannot be distinguished from the better qualities of the pulverulent marls, of which analyses have been given in the early part of this report. Independent of which, its value has been unequivocally tested in other countries, where it has been found to have the most decided ameliorating effects upon land to which it is properly applied.

From what has been said respecting many of the soils of the valley, it is not to be inferred that they are all devoid of calcareous matter, or indeed that this ingredient is not very often present in some proportion, but rather that in few or no instances does it exist in the soil to such an extent as to interfere with the advantageous application of lime or unburnt calcareous manures; and under these views, I would urge upon those who are particularly interested in the success of agriculture in the valley the benefits to be anticipated from the diligent use of the various resources so abundant and accessible throughout this portion of the state.

The *iron ore* of the valley constitutes another of its most valuable possessions. This, although manufactured into iron in numerous places, has as yet been the subject of no systematic geological and

chemical examination, further than the mere determination of its general features, and some of its qualities in the furnace. An examination of the composition of all the principal varieties now in use, as well as the determination of the relations of the deposite geologically with the rocks among which it is found, would furnish matters of inquiry, whose practical bearing upon a valuable branch of industry in this region, will be promptly and fully recognised by all who are interested in its success. For, although the tact of the operator, in this as in almost every department of the arts, is necessary to the profitable pursuit of the manufacture, those engaged in the smelting of iron have long been sensible, at least in other countries, of the high importance of such suggestions as are furnished by a chemical examination of the ores upon which they operate, and a geological investigation of the positions in which the beds of ore occur. The ores almost exclusively in use are hematites of various aspects, known under the names of honeycomb and pipe ores—many of which yield a metal of the very finest character. The facility of smelting, as well as the quality and amount of product, varies of course with the description of ore employed—and from the want of such knowledge as has been just referred to, the difficulties of the process in some places have almost put a stop to the operations of the fnrnace.

A new interest attaches to this branch of industry, at least, in some portions of the valley, from the recent discovery in the immediate neighbourhood of the iron, of beds of a semi-bituminous dry coal, which, if we may trust to the indications of its composition, may hereafter be employed as a most efficient and profitable substitute for charcoal in the furnace. Of this coal, as it occurs in the Catawba mountain, and at other points in the valley, but little as yet is known; but should the hopes excited by analyses which I have recently made of specimens from the former locality, prove to be well founded, a new impulse will be given to the iron manufacture in that district of the state, and rich rewards be proffered to the enterprise of capitalists who engage in it.

Of the various objects interesting to the mineralogist, which are to be found in this region, but little definite knowledge has yet been attained. We may, however, mention carbonate and sulphate of baryta, octahedral and dodecaedral sulphuret of iron, pellucid quartz and crystallized selenite, as occurring more or less abundantly in

different places. Of the lead ore, gypsum, &c. of the south-west, we will speak hereafter.

The numerous extensive caves occurring in this region, form one of its most curious and interesting features, and serve to illustrate some of those geological and chemical agencies to which allusion has been made in explaining certain facts connected with formations in other parts of the state. Thus, in the rich and variegated crystalline deposites and concretions, which render some of the caves objects of so much curiosity to the visiter—the solvent action of water upon the various kinds of rocks composed of carbonate of lime, and the ready tendency of the dissolved matter to separate in a pure and crystallized condition, are both beautifully displayed, while the rounded surfaces of the rocks within the caves, and the generally curved contour of the various apartments, give evidence of the wearing, as well as the dissolving energy of subterranean streams. Usually some *disturbance* of the rocky strata will be seen in and around these caves; and in the various fissures and deep clefts naturally accompanying such dislocations of the strata, we are furnished with a ready explanation of the means by which the agent that has thus scooped them out, originally obtained access to the surface of the rock.

OF THE NORTH MOUNTAIN AND ALLEGHANY REGION.

The numerous ranges of mountains which lie beyond the general limits of the valley, present several features of great practical, as well as scientific interest. In the profile view, a section of the Little North mountain, as presented west of Mossy creek in Rockingham, terminates the line of observation first examined; and the profile is resumed at a point farther south, in a direction from Covington across the Great North mountain into Rockbridge. The lesser ranges of mountains which first interrupt the general undulating surface of the valley, known by the various names of Little North mountain, Catawba mountain, &c., indicate the commencement of a series of rocks entirely distinct from those occurring in the valley, being composed of sandstones and conglomerates, and of shales subordinate to the veins of anthracite and semi-bituminous coal, which here discover themselves. The dip of these, so far as observed during the reconnoissance, is somewhat steeply west, as re-

presented in the profile. A similar direction of the strata is also seen in the range of the North mountain in Rockbridge and elsewhere, but as exhibited in the section of Brown's ridge and the Mill mountain, the dip is east. The rocks composing the North mountain at the place represented in the section, are chiefly sandstones of different hues and textures, with a reddish shale appearing towards the eastern base. Ascending by the eastern side, after passing these shales, we meet with red and gray sandstones; then deep red sandstone with occasional seams of a shale interposed, to near the summit, where we find a heavy stratum of white pinkish sandstone exposing an extensive bared surface, which dips N. W. On the western side following the winding of the spurs, the pinkish variety of rock is succeeded by gray, and thence tracing the mountain to its base, the red and gray varieties appear with changing dip, such as would be explained by the structure indicated in the profile view of this side of the mountain. Pursuing a western course, we find slate dipping to the west for some distance from the flank of the mountain, but assuming an eastern dip as we approach the base of Brown's ridge, where a bed of limestone, with a correspondent dip occurs, after which we come upon the gray and reddish sandstones composing that ridge, which also dip in the same direction.

There being no reason for doubting the identity of the rocks in the North mountain and Brown's ridge, we are led to infer, that immediately at the base of the former there exists a western dipping limestone similar to that with eastern dip at the base of the ridge, but not having detected it in consequence of its being concealed by the fragments of rock collected there, it is not indicated in the figure. The series of rocks thus far, commencing with that which in the horizontal disposition, must have been the lowest, would, therefore, be sandstone, limestone, slate; and this order we shall find prevailing for some distance farther west. The sandstones of Mill mountain, like those of Brown's ridge, dip east, and are separated from the former by an intervening valley of slate, the western portion of which is seen dipping in conformity with the rocks of the Mill mountain, but in the eastern part no rocks *in situ* could be seen on account of the mass of fragments by which they were covered up. From the precipitous escarpments of the two ridges here described, the apparent identity of those rocks of which they consist, and other striking circumstances in the features of the valley, there can be but little

doubt that lines of fault, giving to the strata of sandstone, limestone and slate, originally horizontal, an *eschellon* position, have occasioned this repetition of the rocks of the ridge in the Mill mountain, preserving their dip in the same direction; or more familiarly speaking, these two ridges were thrown up from their horizontal position under such an action of the dislocating force as not to elevate the rock on the western side of each; and, therefore, not to present any strata having a counter or western dip. To present this principle, which is familiar to geologists, in another point of view, the rocks of the Mill, Brown, and North mountain, being rocks of sediment, and having, therefore, been originally horizontal, or nearly so, formed one continuous bed, the sandstone lying beneath, the limestone next, and the slate upon the surface. The disturbing force throwing up the sandstones of the North mountain, gave them a western dip, while other forces dislocating the strata to the west, gave them the parallel but not continuous positions which they now display, Instances of this kind of disturbance are among the most usual in geology, and would readily be inferred by those versed in the subject to have occurred at the points here described, by a simple view of the profile itself.

But it is thought that the explanation above given will aid the general reader, for whom the report is chiefly intended, in understanding the delineation of this portion of our line. West of the Mill mountain to near the base of the Warm Spring mountain, we pass over slates occasionally exposing the subjacent bed of limestone, but throughout this valley scarcely a glimpse of the sandstone which lies still lower can be had. At Bratton's Ridge, the limestone comes boldly out with an eastern dip, and at some distance beyond, a turn not delineated having occurred in the strata, the slate is seen dipping in the opposite direction. This brings us to the little valley of the Millboro' Sulphur spring, which here issues from the pyritous slate —and now the slate is found dipping to the east until another change brings up the limestone into view near the Blowing cave, and the dip becomes west again; after which, with several rolls or undulations as seen in the Cow Pasture hills, it settles into an eastern dip, which continues to the boundary of the slate near the base of the Warm Spring mountain. Here limestone occurs dipping with the slate, and this brings us upon the debris piled upon the skirts of this lofty range. As the structure of the Warm Spring valley will re-

ceive an especial notice, I will defer any further description of the profile for the present.

The region to which the portion of the profile just described refers, abounds in objects of practical as well as curious interest.

The *coals* of the Little North mountain, Catawba mountain, &c. are among the most prominent of these in an economical point of view; and should the reasonable expectations to which their discovery has given rise, not be disappointed, will influence in no small degree the prosperity of one of the most extensive and important regions of the state. From the Potomac to the south-western counties, the minor ranges of mountains, rising in general along the western boundary of the valley, are known to include beds of this mineral in the various conditions of a pure anthracite, and a compound containing variable but never large proportions of bituminous matter, and which may accordingly be denominated semi-bituminous coal. In Berkeley county, on Sleepy creek and elsewhere, openings have been made, from which an anthracite of the very purest character is obtained. In Frederick, Shenandoah, Rockingham, Augusta, Botetourt and Montgomery, similar discoveries have been made; the coal of the four former counties, as far as yet examined, being nearly identical with that in Berkeley, while that found in Botetourt and Montgomery contains a considerable portion of bitumen, though far less than that of ordinary bituminous coal. The veins which have as yet been examined, vary from three to seven feet in thickness. That represented in the profile, dipping west into the Little North mountain, near Coal run, in Rockingham, is about four feet thick. Several openings at different points in the neighbourhood, present no perceptible variation in the character of the coal, which is a pure anthracite, capable, as experiment has shown, of burning with but little flame, and with the production of a very intense heat. At this place, and it would appear also in others in the same range, the coal readily falls into small fragments, exhibiting numerous rubbed and shining surfaces, leading to the impression, which an examination of the enclosing rocks would also indicate, that a dislocation of the strata has occurred, attended with a sliding and grinding action of the roof and floor of the veins, breaking up and fissuring the included coal, and occasioning by the mutual attrition of the contiguous surfaces that peculiar lustre and striated appearance which they invariably exhibit. In some of the veins, however, this crushing effect

appears to have been but little felt, and the coal comes from the vein in larger and more permanent masses. A further exploration of those veins, in which the coal has been thus reduced, may bring to light other portions of the vein, in which comparatively little of this grinding and crushing action has occurred. For some purposes, this broken condition of the coal would not impair its usefulness, but for general sale it would affect its market value.

According to an analysis of the Berkeley *coal*, executed by my brother, Professor H. D. Rogers, it contains in the one hundred grains only 4.94 grains of gray ash, all the remainder consisting of volatile and combustible matter. This indicates a purity exceeding that of the Pennsylvania anthracite in general, which at a mean contains about six per cent. of ash.

In the *coal* from the Catawba, I have found varying proportions of bitumen in the specimens from different localities. An average of these results indicates about 14 per cent. of volatile matter, chiefly of a bituminous character. This coal burns with but little intumescence or swelling, is not much inclined to cake, has no tendency to splinter when burning, and forms a large amount (upwards of 80 per cent.) of a very superior kind of coke. Allusion has already been made to the probable value of this mineral, in connexion with the iron manufacture of this part of the state; but further explorations of these veins, together with careful chemical analyses of the coal as well as iron ore, and actual trials of the former as to its qualities in the furnace, are yet required, in order to determine with certainty the usefulness of this coal in the raw or uncoked condition, in reference to this branch of industry. In connexion with these remarks, and more especially as suggesting an important hint to those who may be endeavouring to bring these dry coals into use in the way alluded to, it may here be added, that from the great success attending the use of the *hot air blast* in France and England, where, in some cases, coals in the raw state, of an analogous character, are employed, the introduction of the same mode of operation here, holds out the promise of most profitable results; and it may be further suggested, that the great efficiency and economy of the *hot air*, even according to the trials made in this country with the ordinary materials used as fuel in our furnaces, ought at once to excite the attention and awaken the enterprise of all who are concerned in this highly important branch of our manufactures.

The sandstones, limestones, and slates of this region, are all of them convertible to useful purposes. The pinkish variety of the former is quarried in the North mountain to furnish hearths for furnaces, and has a hardness and sharp grit, which has led to its employment as a substitute for the more expensive millstones. The slate is largely impregnated with iron pyrites, and upon exposure to the air yields a great quantity of sulphate of iron or copperas, as well as sulphate of alumina or alum. It is for this reason, that the springs of this part of the state so frequently possess a sulphuretted, chalybeate, and acid character, and that some of them are so powerfully remedial in cutaneous and various other diseases. The celebrated alum rock on Jackson's river, consists of nothing but this slate, which here rises in an abrupt and lofty cliff, forming a semi-circle at the bend of the river, and presenting a scene which is at once curious and imposing. Over the surface of the wall-like precipice, streaks and stains arising from the copperas or ferruginous matter of the rock, may everywhere be seen, and large nodules of a spheroidal form, and of the size of a bomb, lie here and there embedded in the mass. Such is the amount of chalybeate and other saline, as well as sulphureous matter in these slates, that the inhabitants of the country, in lieu of resorting to the springs, of which some, as the Alum spring, are much in vogue, are accustomed to make use of the detached fragments of the rock, which in small quantity will impart to water all the flavour and effects of the springs themselves.

Chalybeate and sulphuretted springs break forth in various places from the pyritous slate above described, many of which, as for example, the Botetourt, Augusta, Rawley, Shannondale, Yellow, and Alum springs, have acquired reputation for their medicinal virtues. Thermal waters abounding in free carbonic acid and nitrogen gases, resembling those of the Warm spring valley, occur in some localities, an interesting example of which may be seen in the neighbourhood of Kaiser's, in the gorge of the Rich Patch mountain. Analyses now on foot in relation to the characters of several of those waters, forbid the publication at present of any decisive results, but it is hoped, that by an early day some account of their constitution will be embodied in a treatise on the mineral waters of Virginia, now in course of preparation.

Of the *limestone*, it may be merely stated, that it is capable of fur-

nishing a lime fully equal to that of the valley, and that the extent to which it exists in the deep valleys of this region, renders it accessible for agricultural purposes on almost every farm. Many beautiful and fertile spots possessing the advantages here stated, lie enclosed among these mountains, which, with facilities of transportation, must, at some not distant day, be looked upon as choice places of the state.

Iron ores similar to those of the valley, abound on the flanks of mountains where the limestone occurs, and many successful furnaces are supplied from this source. At Jordan's furnace, near the Mill mountain, castings of a very superior quality are made from a hematite procured in the neighbourhood of Brushy ridge; and at no great distance above, on the Jackson's river, the enormous water power which is here given by the torrent as it makes its way through the Rich Patch mountain, is in part applied to give action to the machinery of a large and successful forge. Facts of this kind, though new to very few, are calculated to fix our attention upon the great resources in materials and motive power which these wild districts of the mountains possess, and thence to illustrate the public advantages which are at some future day to flow from the establishment of proper facilities of communication with them, and the direction of wealth and enterprise to the practical developement of the riches which they contain.

Most of the rocks of this region, contain numerous fossil impressions. The bare sandstones on the summit of the North mountain, seen from the road in passing from Lexington to Covington, display a great profusion of encrini and other zoophytes; and the sandstones of the Mill mountain, Ritch Patch mountain, &c. present similar vestiges of organic life, together with hollow casts and marks of shells. In addition to such traces the surface of these rocks occasionally exposes those waving ridges which are known to geologists as *ripple marks*, and which are referred by them with almost undoubted certainty to the same causes as are found at the present day, producing precisely similar markings upon the sandy surface of the ocean beach. Large exposures of the rocky surface, thus beautifully rippled, may be seen in numerous parts of the North mountain, and the other remoter ranges, and under the above view of the origin of this curious feature of the rocks, are calculated in a

beautiful manner to illustrate the circumstances under which the strata of this region were deposited.

The slates, particularly those in the neighbourhood of the coal veins above referred to, present large and perfect impressions of fern leaves and other vegetable remains; and the limestones are rich in shells and madrepores of various kinds, and often of uncommon size. Fine specimens of terebratula and caryophyllea may often be obtained entire.

A curious and imposing feature in the rocky scenery of many places in this region, is the bent or arched arrangement of the strata. In following the windings of the Jackson's river through the wild and picturesque valleys and gorges by which it makes its way into the more open region towards the east, this strange conformation of the rocks is seen in several places, furnishing in the stupendous elevation of the cliffs, and the massive character of the beds of which these arches are composed, the most instructive and magnificent illustrations of some of those agencies to which geologists are accustomed to refer. One of these instances of bent strata, particularly worthy of observation, is presented in the deep cleft of the Rich Patch mountain, through which the river makes its final escape from the rugged region in which its progress has been previously so much obstructed. Looking from Kaiser's, or the Forge, the naked side of this huge defile, towering in a nearly vertical wall, washed at its base by the impetuous torrent which flows eastward with a rapid descent, exhibits the grand spectacle of an enormous and almost unbroken arch of sandstone rocks, rising at its extremities in steeply dipping lines curving with more gentle inclination to its summit, and spanning a distance of several hundred yards. Thin ledges of a very hard variety of the same species of rock project at the abutments of the arch, and rise along the side of the cliffs in a nearly perpendicular direction. On the oppositie side the same position of rocks is seen; but here, in many places, the continuity of the arch is broken. A similar scene, though on a smaller scale, is presented in the gorge by which the Calf Pasture river finds a passage through the North mountain; and indeed it would appear, that this feature in the position of the strata, is a common occurrence in all the mountainous ranges of this wild and beautiful region.

Proceeding westward in the profile, we come upon the heavy beds

of sandstone of the Warm spring mountain, dipping rather steeply to the east—on the western base of which, we meet with a fossiliferous limestone, having the same dip, and therefore lying beneath the sandstone. Bounding this valley on the west, the Little Warm spring mountain and its prolongations, exhibit the same rocks in the same relative position, with this important difference, that they all dip west. The relation of the rocks thus described, and as they are represented in the section, admits of a simple explanation, by conceiving a violent upthrow to have occurred along the line in which the valley now exists. The sandstones thus thrown off on both sides, left the deep fissure in which the limestones elevated by the same upheaving action, were revealed to observation. In this view, the mountains bounding the valley have been formed merely by the forcible protrusion on either side of beds of sandstone of enormous thickness, which were originally in a horizontal position—and the limestone which appears dipping in opposite directions and beneath the mountains, was brought into view by the same agency, although previous to its elevation it must have existed at a depth of nearly 2000 feet below the surface. This valley has, therefore, the character of an enormous fissure, and considering it in that light, we have no difficulty in accounting for the number of *thermal* springs which it contains. The well established fact that the temperature of the earth's strata increases with their depth from the surface, in connexion with the structure of the valley here described, will at once explain the elevated temperature which all these springs display, while peculiarities in the mineral ingredients of the subjacent beds, which it may readily be imagined would account for the gases which they evolve, as well as the saline and other ingredients which they hold dissolved.

In connexion with these views, it is important to remark, that the fossils and other characters of this limestone distinguish it from those which are found among the mountain chains to the east or west, and that it bears a striking analogy to the fossiliferous limestone formerly described as existing in the great valley of Virginia. Granting the identity of the two, we would thus have the slates and limestones of our valley occupying a position at great depths below the various mountains and valleys we have been describing, and only appearing at the surface where some great uplifting force has

operated, as in the Sweet spring valley, tossing away the upper and more recent strata.

Throughout all the region of which this portion of the profile may be considered as giving merely a local representation, the thermal waters, in virtue of the carbonic acid contained in them, hold in solution large quantities of carbonate of lime. The carbonic acid in quickly escaping from the water by exposure, permits the calcareous matter to separate, and thus, as the stream proceeds, this ingredient is precipitated at every step. Hence it is, that we find the channels of the streams thus impregnated, covered with a hard incrustation, accumulating in thickness every day, and even the stones and twigs over which the current flows, becomes encased in a film of semi-crystalline calcareous matter. Agitation of the water favouring the escape of the solvent carbonic acid, will also contribute to the rapidity of this accretion, and accordingly it is found, that where the ripples are numerous, the deposite is comparatively abundant, and what at first view seems most strange, even the ledges over which the streams are precipitated in cascades are themselves built up by additions of the calcareous deposite. The travertine formations of these valleys, produced in the way we have just described, are in some cases of immense thickness and extent. That in the neighbourhood of the Sweet springs, has in all probability, a thickness in some places of upwards of 100 feet, and every year adds slowly to its amount. At the Falling spring, nearly on the route from Covington to the Hot springs, a still greater depth of this deposite has been accumulated, and in various other places throughout this region, masses more or less considerable of the same curious formation, may be met with in the valleys, and sometimes even at considerable elevations on the sides of the hills.

The travertine, like that already alluded to as existing in Jefferson, Frederick and other counties in the valley, is capable of being made highly useful in agriculture, and of yielding a lime of the greatest purity and whiteness.

In the mountains west of the point last referred to in the profile, we discover the ternary series of sandstone, limestone and slate, as before described; the limestones showing themselves altogether on the flanks of mountains, and then only occasionally peeping forth. As represented in the profile, repeated alternations in the dip of the strata occur in this region, and the structure of the ridges is ge-

nerally such as to present a dip outwards on both their eastern and western sides. Progressing westwards, the overlying slate is increased in thickness by the addition of other, and not exactly similar beds, over which, and generally dipping to the west, we find the sandstones and slates on the western flank of the Alleghany mountain as presented in the neighbourhood of the White Sulphur springs. Among the numerous ranges of similar structure to that exhibited in the profile, and which are usually denoted by the common name of Alleghany, veins of coal have been discovered in many places, and the black shale usually accompanying this mineral is of frequent occurrence. One of these veins is exhibited on the profile, as seen in the vicinity of Crowe's, near the base of the Sweet spring mountain. A similar vein about three miles north of Lewisburg, furnishes a coal which, according to the trials which have been made of it both in smith's forges and in ordinary grates, has been shown to be of good quality. Most, if not all of these coals, are of the semi-bituminous character, and are, therefore, not much prone to cake while burning.

Bands of fossiliferous slate and sandstone are exposed to view in many places among the mountain ridges of this region. The hard dark brownish sandstone, generally seen lying in bands of a few inches thickness, is often largely stocked with fossil impressions. A single stroke of the hammer will frequently reveal, over an extensive even surface of the fractured rock, multitudes of such casts, chiefly the joints of encrini of various species; and so common is the fossiliferous rock throughout these mountains, that a large proportion of the broken masses met with in the channels of the streams and in the numerous dry ravines which form the beds of winter torrents, are rich in curious and instructive fossil traces.

The calcareous matter which once formed so large a portion of these various rocks in the shape of shells and zoophytes, has entirely disappeared, leaving hollow moulds, marking the form and character of the fossils which have been dissolved away. Yet so distinctly do these casts preserve all the delicate lines and marks of their originals or seals, that they furnish the scientific observer with a sufficiently definite knowledge of their peculiarities to enable him to refer them to their proper places in the arrangements of the naturalist, and by comparing them with the fossils of the other

strata and other regions, to make important inferences concerning the geological epoch of their existence.

In the limestones of this region fossil impressions are equally abundant. At Callahan's and near Crowe's, the mass of the rock appears chiefly to consist of solid casts of shells, which, with a little care, may frequently be detached entire, exhibiting unimpaired, all the peculiar features of the shells themselves. Perfect specimens of species of terebratula and productus may be procured at these and numerous other localities; and with a little research, a rich collection of fossils may be gathered in almost any part of this region, comprising a variety of species unknown in the geology of Europe. Seeing, from the character of these impressions, that the living beings whose traces are thus engraved upon the rocks, were once the inhabitants of an ocean, we reflect with wonder upon the curious geological changes which have occurred since the period in which the exuviæ of these shell fish and zoophytes were gradually accumulated in the sand and mud at the bottom of the sea, and we look with new interest and astonishment upon the solid texture and towering height of the rocky strata in which these unequivocal traces of *oceanic life* are thus durably impressed.

One of the most valuable of the rocks occurring in this region, is the brownish slate, of which the firm and even surface of our mountain roads is now frequently formed. The existence of this admirable material immediately adjacent to the roads in many parts of this region has already exerted a most happy effect in their construction and improvement, and has rendered them for beauty and convenience, deservedly the boast of this portion of the state.

The numerous *mineral springs* for which this region is so celebrated, and which, perhaps, constitute its most valuable possession, could not be properly described in the narrow compass of the present report; and as injustice might be done by such meagre notices as it would be possible to introduce, a special description of their character and contents, and of the geological features of the surrounding country, will be reserved for another publication, now in progress, in which such details will be given in all the amplitude they deserve, and from which, should the *minute* geology of this and other parts of the state be called for by the legislature, all the im-

portant particulars bearing upon this point will be borrowed and incorporated in a more detailed report.

Among the general considerations in relation to them, which may with propriety be introduced in this place, it is worthy of remark, that while the thermal springs to which we have referred, in treating of the Warm spring valley and other places, appear to be indebted for their impregnation chiefly to rocks of a calcareous description, and are accordingly found in or near such rocks, the sulphuretted springs now referred to, among which are the White, Red, Salt, Blue and Gray Sulphur springs, appear to derive most of their ingredients from pyritous slates, and will therefore be observed to rise through or in the neighbourhood of strata of this nature. Of these, the White Sulphur is the only one which can be regarded as decidedly thermal, its temperature being about 64°, while the others do not vary considerably from the usual temperature of the ordinary springs around them.

Another point of a general character which may be noticed here, is the radical difference as to saline and gaseous ingredients observable between the springs formerly alluded to, and those of which we now speak. All the waters of the Warm and Hot and Sweet springs valley, and several others of analogous character, and highly thermal temperature, discharge considerable quantities of free gas, consisting of carbonic acid and nitrogen, of which the latter was first distinctly recognised by myself, and found in general to be present in very great proportion.

At the same time a large amount of carbonic acid is held in combination in these waters, imparting the acidulous character for which some of them are remarked, and giving them the power as already mentioned of holding large quantities of carbonate of lime dissolved. This acid impregnation is in no instance more strikingly manifested than in the waters of the Sweet spring valley, of which, that of the Red spring about a mile below the principal fountain of the Sweet springs, presents an amount of the combined gas equal in volume to about one half of that of the water itself.

Another important distinctive feature in the constitution of the class of springs here spoken of, is the large amount of the *carbonates*, principally that of lime, and the comparatively small proportion of the *sulphates* with which they are impregnated.

On the other hand, the class of *sulphuretted waters* as exemplified

in the springs previously named, contain but little carbonic acid, and a comparatively minute amount of carbonate of lime, or other carbonates, while they are richly fraught with sulphuretted hydrogen gas and various sulphates, of which those of lime and magnesia are present in most considerable proportion. Besides the several points of distinction above referred to, it may be further added that the sulphuretted waters are in general impregnated with various organic matters of very peculiar characters, which by collecting in the reservoirs and channels of the springs, in mixture with precipitated sulphur, have, by the various beautiful colours which they impart, given rise to the different appellations by which the more celebrated of these fountains are now known. But while such general resemblances as have been described, will be found to prevail among the several springs of each class as thus characterised, it is at the same time to be remarked that they possess striking individual peculiarities, imparting to each an amount and species of medicinal agency in some degree appropriate to itself.

Viewed singly in relation to the number, variety and high reputation of its mineral waters, this region is well entitled to be proud of the vast resources of which it is possessed. Grouped as these springs are at moderate distances apart, presenting within the same district a variety of medicinal character, for which in other countries, regions remote from each other require to be visited in succession, placed at a point equally accessible to the inhabitants of the seaboard and the great valley of the west, and situated in a region of grateful summer temperature of salubrious climate and of picturesque and of diversified natural beauties, they are now rapidly attaining a celebrity for powerful and varied remedial qualities, as well as for the refined social enjoyments which are annually gathered around them, destined ere long to eclipse the older reputation of the famed fountains of the northern states, and to vie even with the long established character of the most noted of the watering places of the old world.

Among the valuable minerals of this portion of the state, mention should be made of the rich *iron ores* occurring along the ridges in numerous places, and which, from the frequency of coal seams among these monntains will one day be brought into profitable use.

Saltpetre is found mingled with the earth in many of the caves in this region, and has been procured from time to time in con-

siderable quantities from this source. This earth or petre-dirt, as it is called, is obviously a sediment deposited from the waters, formerly or at the present time found within the caves, and has sometimes a texture of such impalpable fineness as to indicate that the deposition took place while the liquid was in a very quiet state. Besides the saltpetre or nitrate of potash, it also contains a large amount of nitrate of lime, which, by the usual process of mingling the washings of common ashes with those of the petre-dirt, is by a direct chemical action converted into saltpetre. Immense heaps of the earth from which the salt was formerly obtained, may be seen in some of the wide chambers of the Singing and otner caves, which there is reason to believe in process of time, will become as rich in this substance as before.

In the same caves *Gypsum* is also found mingled with the petre-dirt, and sometimes enclosing large lumps of it in a thick crystalline envelope. In the Organ Cave so much of it is found both in this condition and replacing the shells originally existing in the slaty limestone, as to make it worthy of inquiry, whether it might be turned to profitable use.

Returning to the profile at the point marking the intersection of Howard's creek with the line of observation, we remark the commencement of a series of sandstones and slates differing from those of the Alleghany, and presenting that want of accordance in the dip which may probably mark the beginning of the great western series. The rocks of the former kind here exhibit what is called a *diagonal lamination*, a structure very general among the sandstones of the west, and one from which the geologist derives important hints as to the natural circumstances existing when these strata were deposited.

On the eastern side of the Greenbrier, is an outlying hill composed of horizontal beds of limestone, resting upon red and green friable slate. At several points south of this, in a direction towards the Salt Sulphur springs and Uniontown, this limestone is discovered, and in proceeding some distance towards these points, the hills as well as valleys present scarcely any other rock but a limestone, which, judging by its fossils and other characters, may be regarded as probably the same as that here represented. Beyond this point, we meet with west-dipping strata of reddish shale, with a thin band of limestone on the descent of the hill, approaching Lewisburg.

This brings us into the fine limestone valley, on the confines of which that town is situated, and here we find the rock dipping at first very gently to the west, then becoming horizontal with slight undulations, covered beyond Tuckwiler's with a soft arenaceous rock, approaching to sandstone in appearance, but which is in reality merely the earthy insoluble portion of an impure limestone, from which the calcareous matter has been all dissolved away. Beyond this point, the limestone rises with an eastern dip, in the neighbourhood of Milligan's creek, after which, at the eastern base of Muddy Creek mountain, it is seen dipping westward beneath and mingled with the strata of soft slate, and again appears on the western side of this ridge near its base, coming out with a dip in the opposite direction. Finally, it shows itself capping the remoter part of Brushy ridge, and dipping in a westerly direction, as if prolonged beneath the heavy beds of slate and sandstone of which the Meadow mountain is composed. After this, it is not observed to re-appear in proceeding further west.

Whether as has been supposed, the limestone which has just been traced, is continuous with the extensive beds of this description which are spread over a wide district to the south, forming but a part of one general deposite of which the horizontal limestones in the vicinity of the Salt Sulphur springs and Uniontown, and even of the red Sulphur, are merely other portions, it would as yet be premature to venture upon deciding. No such identity of fossil and other characters has so far been observed in the rock from these different districts to authorise a generalization of the kind, and it must be left to minute future investigation to ascertain the true relations subsisting between these beds.

The extent of the limestone region south and west of Union, is as yet but imperfectly ascertained. Passing the Gray Sulphur springs, and proceeding to the south-east side of the Peter's mountain, we find around the base of the Angel's Rest and Salt Pond mountains, and throughout the valley in which Parisburg is situated, a wide extending stratum of nearly horizontal limestone, much of which along the New river, is remarkable for containing masses of silicious rock, embedded in its substance, sometimes having the horny aspect and hardness of genuine flints. Most of these fragments, however, are irregular in form, and bear a striking resemblance to the white and very compact sandstone which is seen profusely strewing the flanks of the Peter's mountain for many miles

around. In several specimens, I thought I could perceive indistinct traces of encrini, such as are frequent in that rock. Possibly, however, these masses may have become entangled in cavities on the limestone, in which by chemical action, they were subsequently cemented.

One of the most curious objects in the particular district of which we have just been treating, is the lake near the summit of the Salt Pond mountain. The erroneous impressions and absurd speculations to which it has given rise, will be accepted as an apology for the few descriptive remarks which I shall here present. This beautiful sheet of water is situated at the intersection of the Salt Pond mountain and several of its spurs, and not, as is commonly supposed, on the top of the mountain. Its height above the base of the mountain, is probably from 900 to 1000 feet, but it is surrounded by steep and lofty hills on every side, excepting that by which it is approached, and that through which its waters find a small outlet, falling in a picturesque cascade of great height, and then flowing rapidly into the creek below. The outlet appears formerly to have been deeper than at present, and the extent of the lake was therefore much less that it now is. Rocks and earth gradually accumulating at the passage, have dammed the waters up, and hence the trees and shrubs which grew upon its margin, may now be seen sometimes standing erect at a considerable depth beneath its surface. Its length is about three quarters of a mile—its greatest width about half a mile. By careful soundings from side to side, in many parts of it, the greatest depth that could be found was from 56 to 60 feet; but such was the transparency of the water, that the bottom could be seen nearly in its deepest parts. No animal is found in it but a small species of salamander or water lizard.

Of the *south-west* portion of the state so little is known, further than the existence and value of its gypsum, lead, salt and iron, that no general views, even of its important geological features, can be ventured on with safety for the present. Even the tracing of the limits of those formations that connect a portion of it geologically with the great Virginia valley, would as yet be premature; and of the true character of the more western parts, we have no means at present of forming any accurate opinion. Hence, in introducing the few remarks relating to its structure and economical resources, which I shall presently bring forward, little or no regard will be paid to any imaginary lines of demarkation, which might be conceived

separating from each other the distinct geological formations which there is but little doubt that it includes.

Through an exclusive attention to the direction of the drainage of the northern and eastern portions of this division of the state,—as, for example, in Montgomery county,—the designation of Alleghany has been very strangely and unphilosophically applied to a comparatively elevated portion of the table lands of that county—and guided by the same principle, in tracing a supposed connected chain which forms the water-shed of both the east and west-discharging rivers, the same title has been applied to a portion of the Blue Ridge, constituting the western boundary of Patrick and Grayson counties. Thus we have the same term applied successively to ridges entirely dissimilar in regard to the materials of which they are composed, and the epochs to which they are geologically to be referred; and what is of much more practical importance, mistaken conceptions of the nature and resources of these districts will be almost certainly suggested, on a first view of them, as delineated upon the map, from the prevailing idea, that a continuous mountain chain, thus bearing a common designation along its entire extent, must of course exhibit great similarity in structure and materials throughout all its parts. Nor is this all: by following the fallacious guide of the direction of the drainage, instead of actually tracing continuous ridges, likely to present a general similarity in character throughout, we are in many cases giving an imaginary continuity to elevated portions of land frequently belonging to successive ridges, and thus creating in imagination a connected mountain in a direction or directions in which none such actually exists. Hence, nothing is more common in descriptions than to hear of the Alleghany *passing under* the Peter's mountain, near the Sweet springs, traversing the various ridges to the east until it arrives at Christiansburg, and thence by many crooked courses, tending towards the Blue Ridge, until reaching that mountain, it suddenly cuts it off, and bends its own course to the south-west. But during all this description, the speaker is seldom aware that he is describing what, to a great extent, has no original in nature, and that what he represents as one mountain, a continuation of the great Alleghany of the upper and middle portions of the state, here striking across the numerous ridges to the east, and making in its way in that direction under and over and through the numerous mountains which seem crowded in

a phalanx to resist its course, is, in reality, through much of i
tent, only a series of spurs, sometimes merely elevated table l
dissimilar in structure and origin amongst each other, and onl
sociated in an imaginary connexion by the accidental circums
that they form one portion of the water-shed of the east and
discharging rivers. A more accurate knowledge of the topog
of the state, and more judicious principles in the application of t
will, it is hoped, at some future day, correct this preposterous
in the designation of our mountains, and will substitute on ou
such names as the real constitution of ridges of analogous form
throughout, would render natural and appropriate. Thu
western boundary of Patrick and Grayson ought to be called
Ridge, and no ridge or mountain east of the Peter's mountair
with the least propriety, be entitled Alleghany.

OF THE SOUTH-WESTERN DISTRICT OF THE STATE.

In exhibiting a few particulars relating to mineral structur
resources of the south-west, we will confine our attention chie
the limestone, lead, gypsum, salt and coal, which it possesses.

Much of this region is overspread with fossiliferous limesto
various kinds, as well as other varieties containing no fossils
approaching in some places to the character of marble. Semi
minous coal is found in several localities, as on Strouble's run
in Montgomery, and in other places in the Brushy and Wa
mountain. Iron ore is also abundant in the same districts.

The *lead ores* of Wythe, under judicious management in
working, and with favourable means of conveying the resu
metal to the proper market, could not fail to become a large s
of profit to the state. In the forms of sulphuret and carbonate,
contain a large per centage of the metal, and require no expe
arrangements for the reduction, the sulphur in the one, and the
bonic acid in the other, readily escaping under the application
heat of moderate intensity. Both of these ores are wrough
though of late it would appear that the carbonate is preferred
account, it is said, of its yielding a lead of purer quality. The
phuret, as is frequently the case, contains probably antimony c
senic, perhaps both, while the carbonate is much more likel
include no other metallic ingredient but the lead. Until lately

ore of this description, from its earthy appearance in most cases and its total want of an external metallic aspect, had been rejected as of no value, and it was only by accident that its character was revealed to those who were working in the mines.

The sulphuret or blue ore (galena,) occurs in veins of rotten or chalky limestone; the carbonate, in beds generally situated at the intersection of the veins. In the extraction of the metal the fuel employed is wood, and the operation is performed in a simple reverberatory furnace.

The *gypsum*, as far as certainly known, occurs over a space about 20 miles in length, and half a mile in breadth, but probably the area actually occupied by it is much more considerable. The depth to which it extends in some places is enormously great. It lies in beds between strata of limestone, slate, and sometimes sandstone, and has to be penetrated for a great depth in boring for salt water. In some cases it is said to have a thickness of nearly 300 feet, including the bands of rock among which it is stratified. Its condition is either that of a fibrous crystalline mass of nearly perfect purity, or a granular bluish-gray and veined rock, containing a small amount of earth, but still as little mingled with extraneous matter as any of the imported plaister. This precious material, owing to the difficulty of transportation, is yet unknown at any distance towards the seaboard, but during favourable seasons it is conveyed in arks down the Holston, to the south-western states, and in this way yields a handsome profit. With facilities of transportation, what incalculable benefits might the great valley of Virginia, and much of the region west, as well as east of it, derive from this invaluable deposite, and what an active and productive commerce might it give rise to throughout that region in which it is found.

The *salines* constitute another of the treasures of this district of he state. As yet but little has been done, either towards determin-ng the extent of the saliferous strata, or the chemical nature of the various ingredients, besides the common salt, which the brine holds dissolved. At the salt-works on the Holston, the wells are usually from two to three hundred feet in depth, presenting strata of limestone near the surface, sandstone or slate alternating with beds of gypsum several feet in thickness, next beneath, and finally, a stratum of clay, within which the salt-water is procured. This clay is of a reddish aspect, and a very argillaceous texture, being in all

probability a softened shale, such as that of the brine springs and rock salt of Cheshire in England. In fact, a marked analogy is presented in the structure of the salt region of the Holston, and that of Cheshire. In the latter, beds of *gypsum* are found alternating with strata of indurated clays and sands, approaching to slates and sandstones; and carbonate of lime exists largely in the strata lying near the surface. In all these particulars the salt region of the Holston corresponds with it very closely.

The great value of the Cheshire region, however, results from the heavy beds of rock salt which it includes, and of the existence of such upon the Holston, though far from improbable, no positive testimony has as yet been obtained.

The curious fact, that on some occasions granules or small crystals of salt, are brought up by the water of the wells, is certainly very much in favour of the opinion, that such beds of the massive salt do actually exist at depths to which the borings hitherto made have not extended, and furnishes strong additional incentives to a persevering and thorough exploration by borings in numerous places penetrating to still greater depths.

The proportion of common salt varies with different wells, and even in the same is not perfectly uniform. In some cases 10 gallons of the brine will yield one gallon of salt, in others 16 are necessary. Taking the specific gravity of salt at about 2.5, and allowing something for the interstices in the dry measure, we would have in the former case a strength of about 20 per cent. Gypsum is always present in the brine, and is almost the only impurity in it.

Of the *coal* occurring in Montgomery, and other parts of the S. W. region, nothing at present need be added, as the remarks already made in regard to the beds of the same variety of this mineral, occurring in the Catawba mountain and elsewhere, would be equally applicable to those found further south. Iron ore of a very peculiar character is found in Grayson and Wythe, &c., yielding in some cases by the usual smelting process, a metal having all the qualities of steel.

The composition of this ore, now not known, would throw great light on this interesting result, and might enable those engaged in the iron works of the country, to secure a uniform production of this more valuable form of metal, instead of being subject to the

capricious results of having cast iron at one time, and at another, without any apparent reason, a superior quality of steel.

THE GREAT WESTERN BITUMINOUS COAL AND SALT REGION.

We come now to treat of that enormous area of nearly horizontal strata which we have designated as the fifth great geological subdivision of Virginia. It comprises as already shown, the large territory lying between the western limits of the state and an irregular line of mountain ranges as yet imperfectly determined, but nearly coinciding with the eastern front ridge of the Alleghany, the Greenbrier mountains and the great Flat Top mountain. No section of the whole state offers perhaps so much that is characteristic, either in its physical geography or geological structure, and none holds out richer promise of valuable practical results as soon as it shall be systematically explored. By far the greatest portion, if not all, of its strata, belong to a group of formations, distinguished not only in America but through the world, as being the chief depositories of *bituminous coal.* The title of the western carboniferous region might therefore seem to be appropriately applicable to it, were we sure that it might not convey to geologists and others a possibly erroneous conception of the class of rocks which it comprehends. While it is clearly referable to the general period of the bituminous coal, it is by no means meant to signify that the rocks of the region correspond with any exactitude, or indeed have any mineralogical analogy to the strata which comprise the bituminous coal formation of most geological writers. Nor, on the other hand, is it settled, that the era of their production was precisely the same during which the coal beds of other countries were deposited. We hold it to be altogether premature, while the geologists of America are yet only on the threshold of their researches, to endeavour to establish an identity of *names* between our strata and those of Europe. This too frequent error, prejudges all the broader and more lofty generalizations of the science. In a spirit of caution, therefore, dictated by the many blunders daily committed in the nomenclature of our rocks, we shall abstain from giving them a class of European names, not always indeed applicable in the countries where they are employed, and certainly less so in a region of widely different structure, separated by the great interval of the Atlantic. The little that

can be said in a detailed way upon particular strata will be descriptive, being convinced that points of nomenclature and classification cannot be ventured upon with profit until there shall have been collected a vast deal more minute information than is now before us.

This western section of Virginia is characterized throughout by geographical features of great simplicity. The surface of the region is undulating, and towards its south-eastern limit, mountainous; but the loftiest hills rise in gently swelling outlines, and no very prominent peaks tower in acute and ragged lines, to denote that the strata have been subjected to violent convulsive and upheaving forces. Every thing bespeaks it to have been at one time an expanded plain, gently tilted from the horizontal position, so that its surface and the beds of rock beneath, decline with a slight but very uniform depression, very generally towards the north-west to the valley of the Ohio.

The form, direction and character of both hills and valleys, give evidence that its inequalities of surface were caused by the furrowing action of a mighty and devastating rush of waters, which by a rapid drainage scooped out enormous valleys and basins in the upper strata, the remnants of which are consequently traceable across the widest valleys from hill to hill, holding the same elevation, thickness and inclination to the horizon. It is from this deep excavation of the strata by natural causes, combined with the other important circumstances of a nearly horizontal position, that we are to draw our estimate of the prodigious resources of a mineral kind possessed by the region before us. Whatever valuable materials lie included in the strata of the district, coal, salt, limestone or iron ore, the horizontal position alluded to keeps them near the surface, or at an accessible depth, over enormously wide spaces of country, while the trough-like structure of the valleys, and their great depth, exposes the edges of many of these deposites to the day, under positions in which mining is the easiest imaginable, and with an extent of developement not less accommodating to the researches of the scientific geologist than bountiful to the wants of the community. The same features prevail in the tertiary or tide water district of the state, and ought to awaken there a corresponding feeling of congratulation. The only essential difference of structure, is the far greater depths to which the beds of this western territory have been excavated or denuded. A greater number of strata are there laid

open, contributing to render the deep-seated beds of coal as accessible as the superficial marls of the lower section of the state, and thereby to preserve a beautiful balance in the resources of the two respective regions.

The portion of the profile representing this vast and affluent division of the state, along the particular line to which our observations were chiefly directed, may be regarded as commencing with the Meadow mountain, and extending as far as the Ohio; but by starting from the point here indicated, it is by no means intended to imply that the great western series of secondary rocks here actually commence. So far as an inspection of the ground along the route observed may be regarded as furnishing information upon this interesting point, the probable beginning of this series is to be looked for farther to the east, and in all likelihood, is placed on the western bank of Howard's creek, the only position in which an approach to unconformable stratification was observed. As however we have already described the limestones of the Lewisburg valley and the other strata with which they are immediately associated, and as moreover our chief object at present is the presenting some particulars relating to that portion of the great western series which is first distinctly observed towards the summit of the Meadow mountain, we shall waive all merely scientific inquiries with respect to the precise boundary of the western rocks, and proceed briefly to describe the structure of this region westward from the point already indicated.

Ascending the Meadow mountain, we meet with blue and red slate in a friable condition, until we arrive at a point more than half way to the top, where gray sandstones make their appearance, forming the cap of the mountain, and like the slates beneath, dipping with a gentle inclination to the west; descending on the western side the slates again appear, and continue throughout the whole of the extensive flat reaching to the base of the Little Sewell, on the eastern side of which they are soon lost, and a gray sandstone, like that already remarked, again comes into view. The upper portion of the Little Sewell consists of a gray and white sandstone, identical with that observed in progressing further west. Here one or more seams of coal have been discovered. On the western flank of this mountain, the red slate is again observed dipping gently west beneath the other rocks, and here finally disappearing under the beds

of sandstone accumulating in thickness in our progress west. Continuing in the same direction, a series of these sandstones of various hues and different textures, including numerous seams of coal, and all dipping as before, but with a diminishing inclination, so as in fact to approach nearly to the horizontal, accompany us through the Big Sewell, Davy's mountain, Bracken's Ridge, Dogwood Ridge, Gauley mountain, &c., to a point west of Campbell's creek, where a gentle counter dip of the same rocks may be remarked, soon, however, exchanged for the general direction before observed. Here, as indicated in the profile, three great seams of coal display themselves almost continuously for a distance of about 12 miles, stretching in parallel and nearly horizontal bands along the almost mountainous cliffs forming the boundaries of the rich and lovely valley of the Kanawha in the vicinity of Charleston.

Beyond this point, the level of the country declining, we come upon a series of nearly horizontal arenaceous and argillaceous rocks occasionlly presenting thin beds of limestone of various degrees of purity, in some cases containing sufficient alumina to render it valuable for hydraulic lime. This portion of the series extends as far as the banks of the Ohio.

The sandstones of which it will be seen so large a portion of this region is composed, are remarkable for the enormous size of some of the fossils which they contain, and the shales associated with the coal are even still more rich in some places in these colossal relics of a former world. A striking feature already alluded to in speaking of the sandstones near the valley of Lewisburg, is observed very generally throughout this region, and is exemplified in some of the cliffs of the New river and Kanawha, on a scale of vast extent. I mean the *diagonal lamination* of the rock—or, in other words, a subordinate stratification oblique to the general lines of demarkation of the several parallel beds of which the whole mass of the cliff or mountain is composed. A similar fact was noticed in describing the tertiary rock of broken shells at York, and the beds of gravel observed in the neighbourhood of Richmond and at other places in lower Virginia. In all these cases, a like agency has been at work in producing this curious structure. In all of them we readily discover the action of tides or currents, depositing upon a surface, originally, by some accidental cause, inclining to the horizon, the sands and pebbles, and other materials of the rock, and thus adding

layer after layer of the deposited material in directions parallel to the receiving surface, and therefore oblique to the general horizontal level. Changing intensity or direction in the transporting tide or current, would be accompanied by an alteration in the position or direction of the lamina thus formed—and it is easy to perceive, that an almost endless variety of structure in this respect might thus be readily explained. The fact here noticed, furnishes of itself a striking evidence, were any such wanting, of the submarine origin of the vast region of which we are now treating. But the organic remains which these rocks entomb, at once demonstrate this to have been the fact—the relics of marine animals being the only remains found among the sandstones which are not immediately associated with the coal.

With the view of illustrating the extent of mineral wealth of which this region is possessed, and at the same time of indicating the vast benefits which it may anticipate from a geological and chemical investigation of these resources, I will briefly refer to some of the more important deposites as yet known, of its coal and iron ore and salt.

At Wheeling, and for 14 miles down the river, the cliff or bank presents an uninterrupted bed of highly bituminous coal, upwards of 16 feet thick, and of such a quality, as to furnish fuel for all the dwellings and manufactories of that enterprising and prosperous town. Above and separated by other beds, are two thinner layers of this material, but of an inferior value. Associated with these seams of coal, and lying above the two lower ones, is a bed of limestone of upwards of twenty feet in thickness.

At Clarksburg and northward down the valley of the Monongahela, there exists one of the richest coal deposites in the state. One of the seams in some places in the neighbourhood of this town, is from 10 to 12 feet in thickness, below which, and separated chiefly by a heavy bed of sandstone, there lies a thinner stratum of a more highly bituminous character. These also are associated with a layer of limestone. We may form some idea of the vast extent of these coal seams from the fact, that from some distance above Clarksburg, they may be followed with scarcely any interruptions throughout the whole length of the valley of the Monongahela down to Pittsburg. Ascending the Tygart's valley river, the coal diminishes in thickness and valuable qualities, while the sand-

stones and limestones increase, the latter in the Cheat and other mountains, near the sources of the river, having a thickness of from 60 to 100 feet.

Coal is also found, though in less considerable seams, along the valley of the Little Kanawha. Near Hughes' river, one of its tributaries, it is very abundant; and in the same neighbourhood, springs of petroleum, or rock oil, have been discovered. North and west of this stream on the ridge, selenite or crystallized gypsum is said to occur, though at what place and to what extent, we are not informed.

On the Great Kanawha, the exposure of coal is one of the most extensive and valuable anywhere in the United States, and here from its immediate vicinity to the Salines, its practical usefulness has been tested on a wide and profitable scale. On the Coal, Gauley, and other rivers in this portion of the west, the beds of this mineral are frequently brought to view, and in fact no better general description can be presented of its extent, than that it is almost continuous with the vast beds of sandstone, which spread in nearly horizontal planes over nearly the whole of this broad region.

A coal containing much less bituminous matter, occurs immediately west of the eastern front ridge of the Alleghany, in Hampshire county, lying in nearly horizontal beds, in five successive tiers, and extending for a distance of many miles along the borders of the Potomac. A simple enumeration of the strata here exposed, will furnish an illustration of the resources of this corner of the state, well calculated to inspire astonishment and exultation. Upon a stratum of valuable iron ore, not less than fifteen feet in thickness, there rests a bed of sandstone, upon which reposes a coal seam, three feet thick; above this, another bed of sandstone, then a two feet vein of coal, next sandstone, then another coal seam of four feet; again a stratum of sandstone, and over it a seven feet vein of coal; over this, a heavy bed of iron ore, and crowning the series, an enormous coal seam of from fifteen to twenty feet in thickness.

The Saline formation, associated with the vast strata of sandstone before described, has as yet been almost unexplored, excepting in the valleys of the Great and Little Kanawha. High up, on the New River, and at one or two points on the Greenbrier, salt water has been found, and the erection of salt works has been attempted,

though hitherto these efforts have proved unsuccessful, either on account of the weakness or the insufficient supply of the brine. What may be the result of future research in the region east of that in which the salt manufacture is now successfully pursued, it would be impossible to predict, but from the fact, that the rocks of all this region, and among them the white sandstone from which the brine of Kanawha is procured, have a gentle western dip, it would appear reasonable to infer, that in the range of the Sewell mountains, and some distance east, where these rocks, which at the Salines are many hundred feet deep are brought nearly to the surface, the supply of salt water might in some places be obtained at a comparatively inconsiderable depth, and at all events, considering the continuity and identity of the strata over the whole of this wide area, we may reasonably suppose, that the saliferous bed or beds would be found in nearly every portion of it, though perhaps in many places having too slight an impregnation to render the water yielded, of any value in the manufacture of salt.

On the Great Kanawha, wells of various depths, rarely exceeding 400 feet, have been sunk on both sides of the river above Charleston, throughout a distance of more than twelve miles. The brine thus procured, unlike most other salt waters, contains scarcely any sulphate of lime or gypsum, on which account the process of obtaining the salt in a pure crystalline condition, is attended with fewer difficulties than usual; and for this reason, the alum salt now procured by the improved methods of operating recently introduced, may be regarded as muriate of soda, in almost absolute chemical purity. The importance and value of the Salines in this vicinity, may be inferred from the fact, that about three millions of bushels of salt are now annually made from them, and that in the manufacture of this article alone, more than twice the quantity of coal is consumed every year than is furnished by all the coal mines of eastern Virginia put together. This coal being procured from the hills adjacent to the salt furnaces, is obtained at comparatively little cost: presenting an example of the fortunate adaptation of the resources of a region to each other, of which few equally remarkable are to be met with anywhere in the world. Enterprise incited by so happy a combination of advantages could not fail of bestowing prosperity upon a region which is thus blessed, and we, therefore, find throughout the whole extent of the valley, where

the salt manufacture is pursued, and even over a wide extent of country, connected indirectly with its operations, a degree of activity and industry and wealth, which we would in vain look for in our rural districts generally, and which, when first beheld after quitting the wild and almost uninhabited regions by which the traveller from the east approaches the Kanawha, cannot fail to kindle in his mind a vivid sentiment of pride, astonishment and pleasure.

A general structure in all respects analogous to that presented in the portion of the profile last described, pervades the whole of that vast area of which the boundaries have been approximately stated in the beginning of this division of the report. But with features of strong general resemblance, it must not be imagined that local peculiarities do not exist in the different portions of this region, developing not only many objects of geological and curious interest, but also bringing to light many of the mineral treasures of which this favoured territory is possessed. There is no point of view, however, in which the immeasurable riches of this region are rendered more obvious to our minds, than that of the uniform and continuous structure which has already been described. For, it is in these widely spreading strata of sandstone, that nearly all the boundless treasures of this country are enclosed, and the continuous character exhibited by them, gives the strongest possible assurance of a like uninterrupted extension of the various beds of valuable materials which they include. In this view, how magnificent is the picture of the resources of this region, and how exhilirating the contemplation of all the happy influences upon the enterprise, wealth, and intellectual improvement of its inhabitants, which are rapidly to follow the successive developement of its inexhaustible mineral possessions. In a country where the channels of nearly all the principal rivers have been scooped out in part through beds of coal, where some of them are paved with the richest ores of iron, and where the very rock itself, the sterile sandstone of the cliffs and mountains, is enriched at certain depths with abundant stores of salt, what more is needed to fulfil the happy and glorious destinies that await it, than to awaken enterprise to a due appreciation of the golden promises it holds out, and to direct industrious and active research to the thorough investigation of the character, position, and uses of the treasures it contains?

Note on the fertilizing efficacy of Greensand, extracted from the report on the Geology of New Jersey, by Professor H. D. ROGERS;

"Mr. Woolley, of Poplar swamp, Monmouth county, N. J., manured a piece of land in the proportion of 200 loads of good stable manure to the acre, applying upon an adjacent tract of the same soil, his marl, in the ratio of about 20 loads per acre. The crops, which were timothy and clover, were much the heaviest upon the section which had received the marl, and there was this additional fact greatly in favour of the fossil manure, over the putrescent one, that the soil enriched by it was entirely clear of weeds, while the stable manure had rendered its own crop extremely foul.

"There can be no doubt that 20 loads of marl per acre must be regarded as an unnecessarily bountiful dressing, but computing the relative cost of the two manures when employed in the ratio above stated, we find a considerable disparity of expense in favour of the greensand. Placing the home value of farm-yard manure at 100 cents for each two horse load, and that of the marl at 25 cents per load, we have the expense of manuring one acre 20 dollars, of marling the same 5 dollars.

"Experience has already shown that land once amply marled, retains its fertility with little diminution for at least 10 or 12 years, if care be taken not to crop it too severely; while with all practicable precautions, the stable manure must be renewed at least three times within that interval, to maintain in the soil a corresponding vigour."

PROPOSED PLAN OF THE GEOLOGICAL SURVEY.

The survey should aim at three principal results, each of which is essential to a proper developement of the native mineral resources of the state:

First, the production of a report descriptive of the minute geology, practical and scientific, of all parts of the state.

Second, the construction of a geological map and a series of accompanying sections or profiles, both necessary to a proper exhibition of the geology of the region, and capable of conveying a fund of useful information, which no mere report can.

Third, the formation of a cabinet designed to exhibit the mineral materials described in the report, and represented on the map and sections.

As a mere description of the geology of a country, if unaccompanied by a map and sections, can convey only a very imperfect idea of the structure and relations of its formations, it becomes necessary to have the geographical map as accurate as possible, inasmuch as errors in this will vitiate more or less the geology. The proper basis on which to lay down a geological survey, is a minute topographical map, the production, however, of which at the present time, would be too tardy and too costly. The existing state map being very inaccurate in various points, which, if retained in the geological map, might lead to serious practical mistakes, one duty of this survey should be to rectify such portions of the topography as must be corrected previous to laying down the geology. This implies a certain amount of topographical duty, which it is designed to perform only when rendered necessary by the demands of the geological survey.

To the topographical branch of the survey might be attached two or three extra duties, some of which would greatly promote the strictly geological part of the survey, and in like manner augment largely our stock of useful information upon the internal resources of the state. One should be to procure numerous *barometrical observations* of the heights of our mountains, more especially the gorges and passes over which roads may from time to time be carried. Another ought to embrace a set of observations on the drainage or *water power* of the several hydrographic sections of the state. This

would act usefully in all suggestions for canals, and also tend to the developement of manufacturing enterprise.

A general plan only can be given, according to which, it would be most eligible to enter upon the geological researches, for the movements of those engaged in the survey must be shaped to a considerable extent by the geological relations of the several districts of the state as they are brought to light. It is deemed proper that the first seasons be taken up *in part* in a general exploration of all the principal regions of the state, and in part in a detailed investigation in a systematic order of each class of formations. In this way a multitude of valuable facts easily reached, will be brought to light by the earliest possible day, and the regular execution of the state map will be in progress from the commencement of the survey, and its ultimate completion greatly expedited.

It is proposed to connect with these general examinations, a mass of chemical investigations, intended to be of immediate application in the employment of the materials brought under review; also, to render annual reports upon such points of the survey as are more pressingly wanted, and which are capable of being completed in a single season, reserving the minute and comprehensive description of the whole geology of the state for a general final report. These annual and specific reports can be accompanied by sections across the strata, the execution of which is compatible with much less time than is essential to the construction of the geological map. In this way much definite knowledge can be disseminated without waiting for the final completion of the enterprise, and the map will be greatly benefited by the investigations auxiliary to these profiles.

The facts, and general views of the geological structure of the state, brought to light in the reconnoissance, enable one to suggest nearly the directions most proper for the principal sections or profiles across the formations of the state.

It is proposed to make one lie between the Potomac somewhere near Alexandria and the Alleghany mountain near Cumberland; another from the Atlantic across the Eastern shore and the Chesapeake bay, at a point between the Potomac and Rappahannock rivers, to reach to the Ohio river near Fishing creek; a third to stretch from the Chesapeake bay between the York and James rivers to the Ohio near the mouth of the Little Kanawha; a fourth to commence at the North Carolina line between the Chowan and Roanoke rivers, and

to follow the general line of the Great Kanawha to the Ohio; a fifth to stretch from the North Carolina line, at some eligible point in Patrick county, and to meet the former section at the mouth of the New river; a sixth to reach from the same state line, some where in Grayson county, to the valley of the Guyandotte river, and to pursue the general direction of this to the Ohio.

The detailed location of these six great lines will be made to depend, in great measure, on local features, and the exigencies arising out of the peculiar geology and geography of each belt of country to be traversed. Their positions have been chosen with a view to intersect the greatest number of strata practicable, and in the most advantageous directions for exposing the formation of every geological subdivision of the state. All the principal ridges are crossed nearly at right angles, and an eye has been had to the greater facilities for investigation afforded by the valleys of the large rivers.

As before said, the survey of the zones of country lying along the sections, makes but a portion, and rather the preliminary portion, of the whole survey. In the construction of the map, and the detailed examinations of the systematic survey, the wide tracts of country included between these profiles, would require to be minutely traversed, especially in the longitudinal direction of the strata, to ascertain and depict their boundaries.

A correct knowledge of any region, sufficiently thorough for practical purposes, can only be attained by running from one formation to the neighbouring ones, crossing their boundaries repeatedly in a zigzag course, so as ultimately to cover the whole surface with a net work of lines more or less close, according to the degree of intricacy in the geology of each district; influenced too by the value of the mineral contents of the strata.

It is proposed that the *state cabinet*, which is to grow out of the survey, should be deposited in a suitable apartment in the capitol, accessible to any citizen of the state, seeking the valuable local and specific information which can only be derived from a collection of specimens.

It is contemplated to commence the formation of the cabinet forthwith; that is to say, to accompany each annual report with a suite of specimens illustrative of it—to be grouped according to the most natural order in the mean while, and ultimately to receive a thorough systematic classification.

The specimens ought to consist of the characteristic rocks of each formation, arranged as nearly in the order which they observe in nature as practicable; also the minerals, ores, marls, peculiar soils, organic remains, and other objects to which reference may be desirable by those engaged in agriculture and the arts, or by those who may study the mineral productions of the state, for less specific purposes.

As it is proposed to make a chemical investigation of the composition of these materials an essential feature of the plan, the analyses given in the reports will be annexed to the specimens examined, that thus every one consulting the cabinet may know at the same time the external aspect, and the composition of a substance, capable of useful applications. The analyses essential to this, not the least useful part of the survey, from the arduous nature of the task, will be confined to substances of more immediate interest and utility.

GLOSSARY

OF GEOLOGICAL AND OTHER SCIENTIFIC TERMS.

FROM LYELL'S PRINCIPLES OF GEOLOGY.

Alluvium. Earth, sand, gravel, stones, and other transported matter which has been washed away and thrown down by rivers, floods, or other causes, upon land not *permanently* submerged beneath the waters of lakes or seas. *Etym.*, *alluo*, to wash upon.

Amorphous. Bodies devoid of regular form. *Etym.*, *a*, *a*, without, and μορφη, *morphe*, form.

Amygdaloid. One of the forms of the Trap-rocks, in which agates and simple minerals appear to be scattered like almonds in a cake. *Etym.*, αμυγδαλα, *amygdala*, an almond.

Analcime. A simple mineral of the Zeolite family also called Cubizite, of frequent occurrence in the trap-rocks.

Anticlinal Axis. If a range of hills, or a valley, be composed of strata, which on the two sides dip in opposite directions, the imaginary line that lies between them, towards which the strata on each side rise, is called the anticlinal axis. In a row of houses with steep roofs facing the south, the slates represent inclined strata dipping north and south, and the ridge is an east and west anticlinal axis.

Arenaceous. Sandy. *Etym.*, *arena*, sand.

Argillaceous. Clayey, composed of clay. *Etym.*, *argilla*, clay.

Arragonite. A simple mineral, a variety of carbonate of lime, so called from having been first found in Arragon, in Spain.

Augite. A simple mineral of a dark green or black colour, which forms a constituent part of many varieties of volcanic rocks.

Basalt. One of the most common varieties of the Trap-rocks. It is a dark green or black stone, composed of augite and felspar, very compact in texture, and of considerable hardness, often found in regular pillars of three or more sides, called basaltic

columns. Remarkable examples of this kind are seen at the Giant's Causeway, in Ireland, and at Fingal's Cave, in Staffa, one of the Hebrides. The term is used by Pliny, and is said to come from *basal*, an Æthiopian word signifying iron. The rock often contains much iron.

" *Basin*" of Paris, " *Basin*" of London. Deposites lying in a hollow or trough, formed of older rocks, sometimes used in geology almost synonymously with "formations" to express the deposites lying in a certain cavity or depression in older rocks.

Belemnite. An extinct genus of the order of molluscuous animals called Cephalopoda, having a long, straight, and chambered conical shell. *Etym.*, βελεμνον *belemnon*, a dart.

Bitumen. Mineral pitch, of which the tar-like substance which is often seen to ooze out of the Newcastle coal when on the fire, and which makes it cake, is a good example. *Etym.*, *bitumen*, pitch.

Bituminous Shale. An argillaceous shale, much impregnated with bitumen, which is very common in the coal measures.

Blende. A metallic ore, a compound of the metallic zinc with sulphur. It is often found in brown shining crystals, hence its name among the German miners, from the word *blenden*, to dazzle.

Botryoidal. Resembling a bunch of grapes. *Etym.*, βοτρυς, *botrys*, a bunch of grapes, and ειδος *eidos*, form.

Bowlders. A provincial term for large rounded blocks of stone lying on the surface of the ground, or sometimes imbedded in loose soil, different in composition from the rocks in their vicinity, and which have been therefore transported from a distance.

Breccia. A rock composed of angular fragments connected together by lime or other mineral substance. An Italian term.

Calc Sinter. A German name for the deposites from springs holding carbonate of lime in solution—petrifying springs. *Etym.*, *kalk*, lime, *sintern*, to drop.

Calcareous Rock. Limestone. *Etym.*, *calx*, lime.

Calcareous Spar. Crystallized carbonate of lime.

Calcedony. A silicious simple mineral, uncrystallized. Agates are partly composed of calcedony.

Carbon. An undecomposed inflammable substance, one of the simple elementary bodies. Charcoal is almost entirely composed of it. *Etym., carbo,* coal.

Carbonate of Lime. Lime combines with great avidity with carbonic acid, a gaseous acid only obtained fluid when united with water,—and all combinations of it with other substances are called *Carbonates.* All limestones are carbonates of lime, and quick lime is obtained by driving off the carbonic acid by heat.

Carbonic Acid Gas. A natural gas which often issues from the ground, especially in volcanic countries. *Etym., carbo,* coal, because the gas is obtained by the slow burning of charcoal.

Carboniferous. A term usually applied, in a technical sense, to an ancient group of secondary strata, but any bed containing coal may be said to be carboniferous. *Etym., carbo,* coal, and *fero,* to bear.

Cephalopoda. A class of molluscous animals, having their organs of motion arranged round their head. *Etym.,* κεφαλη, *cephale,* a head, and ποδα, *poda,* feet.

Cetacea. An order of vertebrated mammiferous animals inhabiting the sea. The whale, dolphin, and narwal, are examples. *Etym., cete,* whale.

Chalk. A white earthy limestone, the uppermost of the secondary series of strata.

Chert. A silicious mineral, nearly allied to calcedony and flint, but less homogeneous and simple in texture. A gradual passage from chert to limestone is not uncommon.

Chloritic Sand. Sand coloured green by an admixture of the simple mineral chlorite. *Etym.,* χλωρος, *chloros,* green.

Clinkstone, called also phonolite, a felspathic rock of the Trap family, usually fissile. It is sonorous when struck with a hammer, whence its name.

Coal Formation. This term is generally understood to mean the same as the Coal Measures. There are, however, "coal formations" in all the geological periods, wherever any of the varieties of coal form a principal constituent part of a group of strata.

Conformable. When the planes of one set of strata are generally

parallel to those of another set which are in contact, they are said to be conformable.

Conglomerate or Puddingstone. Rounded water-worn fragments of rock or pebbles, cemented together by another mineral substance, which may be of a silicious, calcareous, or argillaceous nature. *Etym.*, *con*, together, *glomero*, to heap.

Coniferæ. An order of plants which, like the fir and pine, bear cones or tops in which the seeds are contained. *Etym.*, *conus*, cone, and *fero*, to bear.

Crag. A provincial name in Norfolk and Suffolk for a deposite, usually of gravel, belonging to the Older Pliocene period.

Cretaceous. Belonging to chalk. *Etym.*, *creta*, chalk.

Crop Out. A miner's or mineral surveyor's term, to express the rising up or exposure at the surface of a stratum or series of strata.

Crustacea. Animals having a shelly coating or crust which they cast periodically. Crabs, shrimps, and lobsters are examples.

Cryptogamic. A name applied to a class of plants, such as ferns, mosses, sea-weeds, and fungi, in which the fructification or organs of reproduction are concealed. *Etym.*, κρυπτος, *kryptos*, concealed, and γαμος, *gamos*, marriage.

Crystalline. The internal texture which regular crystals exhibit when broken, or a confused assemblage of ill-defined crystals. Loaf-sugar and statuary-marble have a *crystalline* texture. Sugar-candy and calcareous spar are crystallized.

Debacle. A great rush of waters, which, breaking down all opposing barriers, carries forward the broken fragments of rocks, and spreads them in its course. *Etym.*, *débacler*, French, to unbar, to break up as a river does at the cessation of a long continued frost.

Delta. When a great river, before it enters the sea, divides into separate streams, they often diverge and form two sides of a triangle, the sea being the base. The land included by the three lines, and which is invariably alluvial, was first called, in the case of the Nile, a delta from its resemblance to the letter of the Greek alphabet which goes by that name, Δ. Geologists apply the term to alluvial land formed by a river at its mouth, without reference to its precise shape.

Denudation. The carrying away by the action of running water of a portion of the solid materials of the land, by which inferior rocks are laid bare. *Etym.*, *denudo*, to lay bare.

Dikes. When a mass of the unstratified or igneous rocks, such as granite, trap, and lava, appears as if injected into a great rent in the stratified rocks, cutting across the strata, it forms a dike; and as they are sometimes seen running along the ground, and projecting, like a wall, from the softer strata on both sides of them having wasted away, they are called in the north of England and in Scotland *dikes*, the provincial name for wall. It is not easy to draw the line between dikes and veins. The former are generally of larger dimensions, and have their sides parallel for considerable distances; while veins have generally many ramifications, and these often thin away into slender threads.

Diluvium. Those accumulations of gravel and loose materials which, by some geologists, are said to have been produced by the action of a diluvian wave or deluge sweeping over the surface of the earth. *Etym.*, *diluvium*, deluge.

Dip. When a stratum does not lie horizontally, but is inclined, the point of the compass towards which it sinks is called the dip of the stratum, and the angle it makes with the horizon is called the angle or dip of inclination.

Dolerite. One of the varieties of the trap-rocks, composed of augite and felspar.

Dolomite. A crystalline limestone, containing magnesia as a constituent part. Named after the French geologist Dolomieu.

Dunes. Low hills of blown sand that skirt the shores of Holland, England, Spain, and other countries.

Eocene. The great tertiary era is divided into four periods, the first of which is called *Eocene*, Εως, *aurora*, and Καινος, *recent*, indicating that in the beds of this division, we see the first traces or *dawn* of the present order of things. The class of fossils most serviceable in determining the relations of the existing to the extinct species, are *shells*, and it is between these, more particularly that the comparison has been made. Out of about 1200 shells discovered in Europe in this lower division of the tertiary rocks, 38 only are identical with species known to be

living. This small proportion (about 3 per cent.,) varies a little, of course, with the deposites of different regions; and the deposites of this formation, like those of any other are characterised less by the *precise* proportion of their extinct fossils, than by possessing a number of shells peculiar to the particular era, and found in no other tertiary groups.

Estuaries. Inlets of the land, which are entered both by rivers and the tides of the sea. Thus we have the estuaries of the Thames, Severn, Tay, &c. *Etym. æstus*, the tide.

Fault, in the language of Miners, is the sudden interruption of the continuity of strata in the same plane, accompanied by a crack or fissure varying in width from a mere line to several feet, which is generally filled with broken stone, clay, &c.

Felspar. A simple mineral, which, next to quartz, constitutes the chief material of rocks. The white angular portions in granite are felspar.

Ferruginous. Anything containing iron. *Etym., ferrum* iron.

Formation. A group, whether of alluvial deposites, sedimentary strata, or igneous rocks, referred to a common origin or period.

Fossil. All minerals used to be called fossils, but geologists now use the word only to express the remains of animals and plants found buried in the earth. *Etym., fossilis*, anything that may be dug out of the earth.

Galena, a metallic ore, a compound of lead and sulphur. It has often the high appearance of highly polished lead. *Etym.*, γαλσω, *galso*, to shine.

Garnet. A simple mineral generally of a deep red colour, crystallized, most commonly met with in mica slate, but also in granite and other igneous rocks.

Gault. A provincial name in the east of England for a series of beds of clay and marl, the geological position of which is between the upper and lower greensand.

Gneiss. A stratified primary rock, composed of the same materials as granite, but having usually a larger proportion of mica, and a laminated texture. The word is a German miner's term.

Granite. An unstratified or igneous rock, generally found inferior to or associated with the oldest of the stratified rocks, and

sometimes penetrating them in the form of dikes and veins. It is usually composed of three simple minerals, felspar, quartz, and mica, and derives its name from having a coarse *granular* structure; *granum*, Latin for grain.

Graywacke. *Grauwacke*, a German name, generally adopted by geologists for the lowest members of the secondary strata. The rock is very often of a gray colour, hence the name, *grau*, being German for gray, and *wacke* being a provincial miner's term.

Greensand. Beds of sand, sandstone, limestone, belonging to the Cretaceous period. The name is given to these beds because they often, but not always, contain an abundance of green earth or chlorite scattered through the substance of the sandstone, limestone, &c.

Greenstone, a variety of trap, composed of hornblende and felspar.

Grit, a provincial name for a coarse-grained sandstone.

Gypsum, a mineral composed of lime and sulphuric acid, hence called also *sulphate* of *lime*. Plaster and stucco are obtained by exposing gypsum to a strong heat. It is found so abundantly near Paris, that Paris plaster is a common term in this country for the white powder of which casts are made. The term is used by Pliny for a stone used for the same purposes by the ancients. The derivation is unknown.

Hornblende, a simple mineral of a dark green or black colour, which enters largely into the composition of several varieties of the trap rocks.

Hornstone. A silicious mineral substance sometimes approaching nearly to flint, or common quartz. It has a conchoidal fracture, and is infusible, which distinguishes it from compact felspar.

Jura Limestone. The limestones belonging to the oolitic group, constitute the chief part of the mountains of the Jura, between France and Switzerland, and hence the geologists of the Continent have given the name to the group.

Laminæ. Latin for plates; used in geology, for the smaller layers of which a stratum is frequently composed.

Lava. The stone which flows in a melted state from a volcano.

Lias. A provincial name, adopted in scientific language, for a particular kind of limestone, which, being characterised together with its associated beds, by peculiar fossils, forms a particular group of the secondary strata.

Lignite. Wood converted into a kind of coal. *Etym.*, *lignum*, wood.

Lithological. A term expressing the stony structure or character of a mineral mass. We speak of the lithological character of a stratum as distinguished from its zöological character. *Etym.*, λιθος, *lithos*, stone, and λογος, *logos*, discourse.

Littoral. Belonging to the shore *Etym.*, *littus*, the shore.

Loam. A mixture of sand and clay.

Madrepore. A genus of corals, but generally applied to all the corals distinguished by superficial star-shaped cavities. There are several fossil species.

Mammillary. A surface which is studded over with rounded projections. *Etym.*, *mammilla*, a little breast or pap.

Mammoth. An extinct species of the elephant (*E. primigenius*,) of which the fossil bones are frequently met with in various countries. The name is of Tartar origin, and is used in Siberia for animals that burrow under ground.

Marl. A mixture of clay and lime; usually soft, but sometimes hard, in which case it is called indurated marl.

Mastodon. A genus of fossil extinct quadrupeds allied to the elephant. So called from the form of the hind teeth or grinders, which have their surface covered with conical mammillary crests. *Etym.*, μαστος, *mastos*, pap, and οδων, *odon*, tooth.

Matrix. If a simple mineral or shell, in place of being detached, be still fixed in a portion of rock, it is said to be in its matrix. *Matrix*, womb.

Mechanical Origin, Rocks of. Rocks composed of sand, pebbles, or fragments, are so called, to distinguish them from those of a uniform crystalline texture, which are of chemical origin.

Mica. A simple mineral, having a shining silvery surface, and capable of being split into very thin elastic leaves or scales. It is often called *talc* in common life, but mineralogists apply the term talc to a different mineral. The brilliant scales in granite are mica. *Etym.*, *mico*, to shine.

Mica-Slate, Mica-Schist, Micaceous Schistus. One of the lowest of the stratified rocks, belonging to the hypogene or primary class, which is characterised by being composed of a large proportion of mica, united with quartz.

Miocene. This is the period next succeeding the eocene, and embraces a larger share of recent or living species among the organic remains. It is called miocene from μειων, *less*, and καινος, *recent*, implying that the formations in question contain *less* recent than extinct species; or in other words, that the living races are a *minority.* Out of 1021 shells in Europe, 176 only belong to animals now living, making the proportion of the recent species about 18 per cent.

Mollusca, Molluscous Animals. Animals, such as shell-fish, which, being devoid of bones, have soft bodies. *Etym.*, *mollis*, soft.

Mountain Limestone. A series of limestone strata, of which the geological position is immediately below the coal-measures, and with which they also sometimes alternate.

Muriate of Soda. The scientific name for common culinary salt because it is composed of muriatic acid and the alkali soda.

New Red Sandstone. A series of sandy, argillaceous, and often calcareous strata, the predominant colour of which is brick-red, but containing portions which are of a greenish-gray. These occur often in spots and stripes, so that the series has sometimes been called the variegated sandstone. The European formation so called lies in a geological position immediately above the coal-measures.

Nodule. A rounded irregular-shaped lump or mass. *Etym.*, diminutive of *nodus*, knot.

Old Red Sandstone. A stratified rock belonging to the Carboniferous group (of Europe.)

Oolite, Oolitic. A limestone, so named because it is composed of rounded particles, like the roe or eggs of a fish. The name is also applied to a large group of strata, characterised by peculiar fossils, because limestone of this kind occurs in this group in England, France, &c. *Etym.*, ωον, *oon*, egg, and λιθος, *lithos*, stone.

Organic Remains. The remains of animals and plants (*organized* bodies) found in a fossil state.

Orthocerata, or *Orthoceræ.* An extinct genus of the order of Molluscous animals, called Cephalopoda, that inhabited a long cham-

bered conical shell, like a straight horn. *Etym.*, ορθος, *orthos*, straight, and κερας, *ceras*, horn.

Outliers. When a portion of a stratum occurs at some distance, detached from the general mass of the formation to which it belongs, some practical mineral surveyors call it an *outlier*, and the term is adopted in geological language.

Oxide. The combination of a metal with oxygen; rust is oxide of iron.

Oxygen. One of the constituent parts of the air of the atmosphere; that part which supports life. For a further explanation of the word, consult elementary works on chemistry.

Pelagian, Pelagic. Belonging to the *deep* sea. *Etym.*, *pelagus*, sea.

Petroleum. A liquid mineral pitch, so called because it is seen to ooze like oil out of the rock. *Etym.*, *petra*, rock, and *oleum*, oil.

Pisolite. A stone possessing a structure like an agglutination of peas. *Etym.*, πισον, *pison*, pea, and λιθος, *lithos*, stone.

Pit Coal. Ordinary coal; called so because it is obtained by sinking pits in the ground.

Pitch Stone. A rock of a uniform texture, belonging to the unstratified and volcanic classes, which has an unctuous appearance like indurated pitch.

Pliocene. This is derived from πλειων, *more*, and καινος, *recent*, and is founded upon the existence, in the beds which it embraces, of a *greater* number of recent than extinct species. The pliocene rocks are referred to two periods, the Older Pliocene and Newer Pliocene; In the newer pliocene, the number of extinct species is extremely small.

Plutonic Rocks. Granite, porphyry, and other igneous rocks, supposed to have consolidated from a melted state at a great depth from the surface.

Porphyry. An unstratified or igneous rock. The term is as old as the time of Pliny, and was applied to a red rock with small angular white bodies diffused through it, which are crystallized felspar, brought from Egypt. The term is hence applied to every species of unstratified rock in which detached crystals of felspar are diffused through a base of other mineral composition *Etym.*, πορφυρα, *porphyra*, purple.

Precipitate. Substances which having been dissolved in a fluid, are separated from it by combining chemically and forming a solid which falls to the bottom of the fluid. This process is the opposite to that of chemical solution.

Producta. An extinct genus of fossil bivalve shells, occurring only in the older secondary rocks. It is closely allied to the living genus Terebratula.

Pyrites. (Iron.) A compound of sulphur and iron, found usually in yellow shining crystals like brass, and in almost every rock stratified and unstratified. The shining metallic bodies, so often seen in common roofing slate, are a familiar example of the mineral. The word is Greek, and comes from πυρ, *pyr*, fire, because, under particular circumstances, the stone produces spontaneous heat and even inflammation.

Quartz. A German provincial term, universally adopted in scientific language, for a simple mineral composed of pure silex, or earth of flints: rock-crystal is an example.

Sandstone. Any stone which is composed of an agglutination of grains of sand, whether calcareous, silicious, or of any other mineral nature.

Saurian. Any animal belonging to the lizard tribe. *Etym.* σαυρα, *saura*, a lizard.

Schist. Synonymous with slate. *Etym.*, Schistus, adj. Latin; that which may be split, from the facility with which slaty rocks may be split into thin plates.

Seams. Thin layers which separate two strata of greater magnitude.

Secondary Strata. An extensive series of the stratified rocks which compose the crust of the globe, with certain characters in common, which distinguish them from another series below them, called *primary*, and from a third series above them called *tertiary*.

Sedimentary Rocks, are those which have been formed by their materials having been thrown down from a state of suspension or solution in water.

Selenite. Crystallized gypsum, or sulphate of lime—a simple mineral.

Serpentine. A rock usually containing much magnesian earth, for the most part unstratified, but sometimes appearing to be an

altered or metamorphic stratified rock. Its name is derived from frequently presenting contrasts of colour, like the skin of some serpents.

Shale. A provincial term, adopted by geologists, to express an indurated slaty clay. *Etym.*, German *schalen*, to peel, to split.

Shell Marl. A deposite of clay, peat, and other substances mixed with shells, which collects at the bottom of lakes.

Shingle. The loose and completely water-worn gravel on the sea-shore.

Silex. The name of one of the pure earths, being the Latin word for *flint*, which is wholly composed of that earth. French geologists have applied it as a generic name for all minerals composed entirely of that earth, of which there are many of different external forms.

Silicious. Of or belonging to the earth of flint. *Etym.*, *silex*, which see. A silicious rock is one mainly composed of silex.

Silt. The more comminuted sand, clay, and earth, which is transported by running water. It is often accumulated by currents in banks. Thus the mouth of a river is silted up when its entrance into the sea is impeded by such accumulation of loose materials.

Simple Mineral. Individual mineral substances, as distinguished from the rocks, which last are usually an aggregation of simple minerals. They are not simple in regard to their nature, for, when subjected to chemical analysis, they are found to consist of a variety of different substances. Pyrites is a simple mineral in the sense we use the term, but it is a chemical compound of sulphur and iron.

Stalactite. When water holding lime in solution deposites it as it drops from the roof of a cavern, long rods of stone hang down like icicles, and these are called *stalactites*. *Etym.*, σταλαζω, *stalazo*, to drop.

Stalagmite. When water holding lime in solution drops on the floor of a cavern, the water evaporating leaves a crust composed of layers of limestone: such a crust is called *stalagmite*, from σταλαγμα, *stalagma*, a drop, in opposition to *stalactite*, which see.

Stilbite. A crystallized simple mineral, usually white, one of the Zeolite family, frequently included in the mass of the trap rocks.

Strata, Stratum. When several rocks lie like the leaves of a book, one upon another, each individual forms a *stratum;* —strata is the plural of the word. *Etym.*, *stratum*, part of a Latin verb signifying to strew or lay out.

Strike. The direction or line of bearing of strata, which is always at right angles to their prevailing dip.

Syenite. A kind of granite, so called because it was brought from Syene in Egypt.

Synclinal Axis. When the strata dip in opposite directions towards a common central imaginary line, it is called a synclinal line or axis.

Talus. When fragments are broken off by the action of the weather from the face of a steep rock, as they accumulate at its foot, they form a sloping heap, called a talus. The term is borrowed from the language of fortification, where *talus* means the outside of a wall of which the thickness is diminished by degrees, as it rises in height, to make it the firmer.

Tertiary Strata. A series of sedimentary rocks, with characters which distinguish them from two other great series of strata,—the secondary and primary, which lie *beneath* them.

Testacea. Molluscous animals, having a shelly covering. *Etym.*, *testa*, a shell, such as snails, whelks, oysters, &c.

Thin out. When a stratum, in the course of its prolongation in any direction, becomes gradually less in thickness, the two surfaces approach nearer and nearer; and when at last they meet, the stratum is said to thin out, or disappear.

Trap and *Trappean Rocks.* Volcanic rocks composed of felspar, augite, and hornblende. The various proportions and state of aggregation of these simple minerals, and differences in external forms, give rise to varieties, which have received distinct appellations, such as basalt, amygdaloid, dolorite, greenstone, and others. The term is derived from *trappa*, a Swedish word for stair, because the rocks of this class often occur in large tabular masses, rising one above another, like the steps of a staircase.

Travertin. A concretionary limestone, usually hard and semi-crystalline, deposited from the water of springs holding lime in solution. *Etym.* This stone was called by the ancients Lapis Tiburtinus, the stone being formed in great quantity by the river Anio, at Tibur, near Rome. Some suppose travertin to be an abbreviation of trasteverino from trans-tiburtinus.

Tuff or *Tufa.* An Italian name for a variety of volcanic rock of an earthy texture, seldom very compact, and composed of an agglutination of fragments of scoriæ, and loose matter ejected from a volcano.

Turbinated. Shells which have a spiral or screw-form structure. *Etym.*, *turbinatus*, made like a top.

Unconformable. See Conformable.

Veins, Mineral. Cracks in rocks filled up by substances different from the rock, which may either be earthy or metallic. Veins are sometimes many yards wide; and they ramify or branch off into innumerable smaller parts, often as slender as threads, like the veins in an animal, and hence their name.

Wacke. A rock nearly allied to basalt, of which it may be regarded as a soft and earthy variety.

Zeolite. A family of simple minerals, including stilbite, mesotype, analcime, and some others, usually found in the trap or volcanic rocks. Some of the most common varieties swell or boil up when exposed to the blow-pipe, and hence the name ζεω, *zeo*, to boil, and λιθος, *lithos*, stone.

Zoophytes. Corals, sponges, and other aquatic animals allied to them, so called because, while they are the habitation of animals, they are fixed to the ground, and have the forms of plants. *Etym.*, ζωον, *zoon*, animal, and φυτον, *phyton*, plant.

ERRATA.

Insert a comma after *above*, in line 24, page 17.
Add an *s* to *limestone*, in line 26, page 30.
For *strata*, read *stratum*, in 3rd line from bottom, page 35.
Dele the word *which*, in line 26 of page 104.
For *becomes*, read *become*, in line 12, page 105.

FIRST

REPORT

OF THE PROGRESS OF

THE GEOLOGICAL SURVEY

OF THE

STATE OF VIRGINIA,

FOR THE

YEAR 1836.

BY WILLIAM B. ROGERS,

PROFESSOR OF NATURAL PHILOSOPHY IN THE UNIVERSITY OF VIRGINIA.

PHILADELPHIA:

C. SHERMAN & CO. PRINTERS.

1838.

Office of the Board of Public Works, January 21, 1837.

SIR,

I transmit to you herewith, to be laid before the general assembly, the annual report required by law, of the progress made during the last twelve months by the state geologist, in executing the duties with which he is charged.

The contents of this document bear ample evidence of the zeal, diligence and ability, which Professor Rogers has brought to the task, and vindicate, even thus early in its progress, the wisdom of the interesting enterprise in which the state has embarked. In the tendency of the views presented by it to give a true direction to individual adventure, by showing what it may be safe, what hazardous and what hopeless to undertake, we see the promise of a result of incalculable practical value to the community when these suggestions shall assume the character of scientific deductions based on an ample foundation of well ascertained facts.

The picture it presents of the unlooked for extent and value (great as they were known to be) of the mineral resources of Virginia, and the hopes it inspires of the early reanimation of her power and prosperity through the developement of these resources, cannot be viewed by her citizens but with unmixed gratification.

To realise at as early a day as practicable the important results fairly to be anticipated from the completion of the survey, will be readily admitted to be a matter of much public interest. In view of which, this board, concurring in the reasons presented in the report for a more extended and efficient organisation of the geological corps, beg leave respectfully to recommend the enlargement of it there proposed to the favourable consideration of the legislature.

I have the honour to be,

Very respectfully,

WYNDHAM ROBERTSON, *Pres't*
Of the Board of Public Works.

To the Honourable the Speaker of the House of Delegates.

REPORT.

I beg leave to make the following report of the progress of the geological survey of the state during the past year.

Proper assistants having been appointed, as provided in the law, the active investigations in the field were begun about the middle of April, and were continued without interruption until the beginning of November. During this time and nearly up to the present date, whilst not myself engaged in the task of exploration, the chemical researches connected with the survey have been steadily progressing under my immediate and constant superintendence.

In aid of the field operations and as an important preliminary to the correct delineation of geological details upon the state map, the work of taking accurate copies of the county maps was begun early in the season, and has progressed so far as that at the present time more than fifty of these maps are ready for the uses of the survey.

In the course of the geological investigations of the season upwards of twenty boxes of specimens were collected, illustrating the structure and the economical resources of the various districts visited, and furnishing materials for analytical examination.

In the prosecution of the work, each of the following regions was more or less the theatre of research.

1st. The peninsula of the Potomac and Rappahannock rivers.

2d. The counties bordering on the Rappahannock to the south.

3d. The bituminous coal fields of Henrico, Goochland, Chesterfield and Powhatan counties.

4th. A portion of what is called the Gold region in the counties of Fauquier, Spottsylvania, Culpeper, Louisa, Orange, Goochland, Fluvanna, and Buckingham.

5th. A transverse belt of country extending westward from

the neighbourhood of Fredericksburg to the vicinity of Moorfield in Hardy county.

6th. The northern counties of the valley from the Potomac to the neighbourhood of Luray and Newmarket, together with a portion of the adjacent mountain district to the west.

7th. The counties of Washington, Wythe, Smyth, Montgomery and Grayson, in the south-west.

In most of the districts above enumerated the investigations were conducted in the manner of a reconnoissance with the view of establishing a basis for future specific and accurate research, and it is important to bear in mind that from the diversified features of our geology and the almost total absence of any knowledge of it from previous investigation, such preliminary surveys in each district become indispensable to the successful and rapid prosecution of the minute inquiries which are to constitute the chief value of the survey. But while for the most part the operations of the past year were of the general character here described, in some districts the observations were carried into minute detail, and in all of them a great number of facts were gathered calculated to illustrate their geological structure and the nature and extent of their mineral resources.

As, however, the exhibition of details at present would obviously be incompatible with the design of "the annual reports upon the progress of the survey" contemplated in the law—they will be reserved for incorporation in the final report—in the mean while having the benefit of a revision with the additional lights acquired in the prosecution of the work.

In the first of the regions above indicated, the observations were very numerous and minute. Nearly all the important exposures illustrating the geology and mineral resources of the peninsula were carefully examined; the strata observed in each, being noted, and specimens retained for illustration and chemical research. The boundaries of the two divisions of the Tertiary, the Eocene and Meiocene, were determined with all needful accuracy upon the Potomac and Rappahannock, and were approximately settled as to intermediate points.

The disposition and nature of the beds composing the Meiocene in this portion of the state were found to be conformable

with those of the peninsula of the James and York rivers, chiefly referred to in the report of the reconnoissance published last year. Here as well as in that region the *bluish marls* were found low down in the series of Meiocene strata, and a thin band of ferruginous rock or clay was generally observed to be interposed between them and the diluvial sand and gravel. Indeed so uniform is the position of this layer, in relation to the marl, that *its discovery at any point would furnish grounds for the strong if not confident anticipation of finding marl beneath.*

A large proportion of the marl beds of the Neck, containing carbonate of lime in sufficient quantity to prove available in agriculture, are of the description which has just been noticed; at the same time strata in which the shells are mingled with sand and clay of various shades of yellow and brown are not unfrequent. A fragmentary rock, consisting of broken shells cemented by carbonate of lime, sometimes partially crystallized, and white pulverulent or chalky marls are also found.

Of these the most abundant or *blue marl* though often presenting the appearance of great richness from the number of perfect shells which it contains, has been found to be less charged with carbonate of lime than some of the other varieties.

The mean of upwards of fifty specimens of this description which have been analyzed in the course of the season is 36 per cent. of carbonate of lime, and in few instances did the result rise as high as 40 per cent., while the light-coloured rocky and chalky marls yielded a proportion more than twice as great.

In general the upper beds of the Meiocene in this district were found to be destitute of fossils though full of their casts and impressions. These strata consisting for the most part of light-coloured sandy clays, frequently of great depth, are distinguished by a sulphureous smell, and often by an acid and styptic flavour. They rarely contain an appreciable amount of carbonate of lime, but are impregnated with sulphate of lime (gypsum,) together with sulphate of iron (copperas,) sulphate of alumina, sulphur, and sometimes even a sensible amount of sulphate of magnesia (Epsom salts.) The acidity of these clays is often sufficient to make a pungent impression on the tongue, and their sulphur is distinctly recognized by the characteristic odour exhaled, especially

when they are heated. In many localities, as in the Rappahannock cliffs in Richmond county, the gypsum occurs in crystals of sufficient magnitude to be separated by the fingers, and sometimes in the attractive form of transparent *Selenite*, but its more usual condition is that of delicate silken crystals distributed through the mass and visible only upon close and attentive inspection.

Numerous specimens, taken from strata of this kind in various parts of the Neck, presented a great similarity of composition, though not without much variation in the proportion of the gypsum and other ingredients which they contained, and like results were obtained from the analysis of the overlying and once fossiliferous beds in other places where the Meiocene marl occurs. The cause of the extensive destruction of shelly matter once imbedded in these clays, was clearly traced to the *sulphuric acid* originating in the decomposition of sulphuret of iron, which permeating the beds of marl, converted the carbonate into sulphate of lime. This being in part retained, formed the crystals of gypsum now discovered in these strata. At the same time, that by the decomposition of the sulphuret, the sulphate of iron and other ingredients above noticed were brought to light; and the overlying layer of ferruginous rock or clay most probably owes its origin to the same source.

The presence of gypsum in these beds suggests the interesting inquiry as to how far they may become available in the agriculture of this and other regions similarly situated. Upon this point I shall embrace the present opportunity of a few brief remarks. Where they contain a considerable amount of this ingredient, say 10 per cent., and are impregnated with no injurious or counteracting agent, no doubt can exist as to their beneficial influence upon the soil; and in such cases besides the peculiar ameliorating effect of the gypsum, they would impart the further advantage of an improvement in the texture of the land. But as in most instances the proportion of gypsum does not exceed two per cent., and as it is blended with the other sulphates as well as free sulphuric acid and sulphur, ingredients which in considerable quantity are known to be destructive to vegetation, it would naturally be inferred that such materials, if not inert, must

be actively injurious in their effects upon the soil. Experience too has seemed to give authority to this opinion, since when applied to the land, as in some cases these materials have been in considerable quantities, a diminution or even temporary loss of productiveness has ensued. Still, however, it should be remarked that experiments thus roughly made, by no means justify any confident conclusion on the subject. The effect of such substances on vegetation must greatly depend on the *quantity* in which they are applied. When prodigally spread over the land, there can be no doubt that they inflict serious, though by no means irreparable injury. Such also is known to be the consequence of a redundant application of the ordinary calcareous manures. But observation would seem to prove that, when *sparingly employed*, the materials referred to are productive of a very decided improvement. In many parts of lower Virginia these gypseous and acidulated clays, applied under the impression that they contained a useful proportion of green sand, have been found to impart new and surprising energy to the soil.

Without entering upon the obscure question of the *modus operandi* of mineral substances, including calcareous manures, upon plants, we cannot doubt that in part, at least, their influence is that of directly stimulating the vital organs concerned in vegetable growth,—nor can we avoid believing that with plants as with animals the number of substances adapted to produce this effect is far from being restricted to the few materials most commonly in use. We have the positive testimony of numerous experiments to prove that many substances of high chemical energy are capable in small quantities of favouring the growth of plants.

Without, therefore, advancing any hypothesis as to the peculiar agency of the sulphates and other matters contained in these gypseous clays, or attempting *a priori* to pronounce upon their effects either as salutary or injurious, I feel sufficiently sustained by observation in expressing it as my opinion that they will one day be made available in the agriculture of this region—and I would urgently suggest the importance of making careful experiments to determine the quantity in which they may be safely and advantageously applied. But in all such trials let it be borne

in mind that only *small quantities* of such of these materials as are *strongly styptic* and *sulphureous* should be employed.

The Eocene strata of the peninsula are comprised in the district lying between a line connecting Mathias's point on the Potomac with the mouth of Chingoteague creek on the Rappahannock, and another and crooked line nearly coinciding with the eastern boundary of the sandstone formation in Stafford county, these beds were found to exhibit less uniformity of arrangement than those on the Pamunkey and James rivers, formerly described. In general, the lowest stratum is of a dark greenish blue colour, and those which lie above it have various shades of yellow, greenish gray and brown. In many instances the upper strata are devoid of shells, but replete with their casts and impressions, and with the exception of generally containing a notable amount of green sand, are strikingly analogous in composition to the gypseous and sulphureous strata of the Meiocene. To make the resemblance still more complete, a thin layer of ferruginous gravel or rock frequently overlies these beds, and forms the boundary between them and the Meiocene.

This remarkable resemblance in the situation and character of the two, while it leads us to infer the action of like chemical agencies upon both, assures us of a similarity in their agricultural effects.

The Eocene marls of the peninsula present much diversity of composition. Whilst in some localities the shelly matter forms a very considerable part of the mass, in others little or none of it occurs. The green sand often forms a prominent ingredient, and is in no case absent, though frequently the amount of it is very inconsiderable. Gypsum is also occasionally to be met with; and this as well as the other sulphates is not excluded from the beds containing shells. A minute analysis of some of the more important of these marls is now in progress, but the research is one requiring much time for its completion.

It may be useful to state, that in general the shelly strata of the Eocene in this district do not contain more than from ten to fifteen per cent. of carbonate of lime, and that in many instances, where the shells are quite conspicuous, the proportion is less than one half of this. In the shell rock, such as occurs in seve-

ral places on the Potomac, as much as eighty-two per cent. has been found.

It would therefore appear, that while in some instances there is a sufficient amount of carbonate of lime in the mass to give it the character of a rather poor calcareous marl, the proportion of this ingredient in general is too inconsiderable to impart any high degree of agricultural value. For much of the benefit derived from the application of these substances to the soil we must look to the green sand, gypsum, and perhaps other ingredients which they contain. Experiments now in progress with some of the varieties containing little or no shelly matter, indicate decidedly beneficial results; and there is but little reason to doubt that more extensive trials of these materials, conducted with judgment and caution, will confirm the views at present entertained of their capacity of being highly useful in agriculture.

From the absence of shelly matter in the strata of Meiocene and Eocene above referred to, they have hitherto been considered as entirely destitute of value. The fact now made known of their containing, nearly in every case, a notable amount of gypsum, must therefore be looked upon as an interesting discovery, and should the observations already made, upon the fertilizing effects of the material of these beds, be sustained by a wider and more varied experience, our views of the agricultural resources of the eastern portion of our state will be greatly and cheeringly enlarged. Believing that such is to be the result of further experiments on the subject, I look with pleasing anticipation to the time when the invaluable shell marl of the country will not be without a substitute in those districts to which it has been denied, and *when almost every ravine in eastern Virginia will be resorted to for materials to improve the productiveness of the soil.*

The researches in the counties bordering on the Rappahannock to the south, were chiefly confined to an inspection of localities of marl and the examination of the strata associated with it in several of the more important points. The numerous specimens of the Meiocene marl which were collected in the reconnoissance, have been submitted to analysis, and with the same general results as have been stated in regard to the marls of the Neck, the pulverulent and light-coloured varieties always

yielding a much larger per centage of carbonate of lime than the blue marl, and sometimes, as in the case of specimens from Mr. Oak's and other places in Middlesex, amounting to about 80 per cent. Gypseous and sulphuretted clays were found here as in the Neck, and at some points immediately on the river the *Selenite* was discovered in conspicuous crystals. An analysis of some of these gypseous clays gave from 8 to 10 per cent. of this ingredient.

Before concluding this sketch of the investigations in the Tertiary region during the past year, it may be well to remark that in the event of an ampler organization of the means of exploration, urgently demanded by the survey, the revision of the ground already traversed will be aided by the employment of a boat built and equipped for the service. With such facilities, the exploration in districts hitherto unexamined, will be carried on with increased accuracy and speed.

The researches which were made in *the bituminous coal fields of Henrico, Goochland, &c.* were in the first place directed to the determination of the boundaries of the region in which the coal measures occur. With this view, it was explored by transverse lines, and throughout its entire circuit; but further examinations are required to ascertain its extent and structure with the degree of accuracy necessary to represent it on the map. And before this delineation can be usefully made, the important errors in this portion of the map will require to be corrected.

All the important workings for coal, together with a large number of shafts or diggings of minor interest, were examined; but additional investigations are required to secure that exact knowledge of the complicated structure of these coal fields, which may serve hereafter as a guide to enterprises in this region. I feel safe, however, in remarking that the observations thus far made, whilst they indicate that the region containing coal is more extensive than I had supposed—are calculated to strengthen the opinion that in no part of the basin is the depth of the coal so great as from a view of the directions of its outcrop would be supposed—and if, as is probably the case, the floor upon which it rests is of so undulating a figure as in some measure to divide the region into several basins—there is a reasonable hope of

reaching this mineral at comparatively moderate depths even in the centre of the field.

Although these coals have long been extensively in use for domestic and manufacturing purposes, no systematic investigation of their *chemical composition* has hitherto been attempted, nor have any just data been furnished for comparing them with the coals of other regions, either in this country or abroad. The minute investigations on this subject in which I am now engaged, have already made me accurately acquainted with the composition and heating powers of upwards of twenty of these coals, and I feel no hesitation in saying, in view of these results, that I am prepared to vindicate their claim to a very high rank in comparison with the coals of most other parts of the world. Without entering into details, it may be useful to state that in the specimens hitherto examined the amount of bituminous matter varied from 27 to 38 per cent. of the whole, the ash in general from 2 to 5, and that the combustible value or heating power of the several specimens, as determined by a very perfect process—is represented by an amount of pure charcoal from 75 to 89 hundredths of the whole weight of the coal.

Whilst referring to the valuable character of these rich deposites of bituminous coal, I am anxious again to call attention to the *Iron ores* which accompany them in several places. Since the former report, in which allusion was made to the probable importance of these ores to the manufacturing industry of eastern Virginia, several specimens have been submitted to chemical analysis, and from the results obtained, the really valuable character of the ore may be considered as satisfactorily established.

A specimen of Hematitic ore from the neighbourhood of Trabue's pits in Chesterfield, gave in the 100 grains the following ingredients:

Per oxide of iron, - - -	85.15
Silica, - - - -	4.20
Alumina, - - - -	4.00
Water, - - - -	6.50

The existence of this mineral in immediate contiguity with the coal is a fact of such obvious importance, that no commentary is needed to make it deeply interesting to persons of capital

and enterprise, who may be concerned in developing the sources of this portion of the State.

In that portion of what is called the gold region of the st in which research was prosecuted, all the important openi were visited in which the precious metal is or has been obtain Many circumstances of practical and scientific interest conne ed with each of them were noted, and suites of illustrative s cimens procured. But much additional observation is requi before it will be safe to speak confidently of the geology of th veins or to pronounce upon the extent to which they are lik to contribute to the resources of the state.

I would not have it inferred from these remarks, that any favourable impression as to the ultimate value of our gold mi has grown out of the various facts relating to them which h been thus far collected. On the contrary, I am still of the opin that the working of the innumerable auriferous veins of this w region is destined to become an important branch of the sy matic industry of the state. And whilst I would deprec those overwrought anticipations of their productiveness wh the brilliant developements occasionally made are calculated inspire, I would give a sober encouragement to the enterp and capital which they attract, believing that in many instan these veins have that wholesome degree of fertility which is pable of giving to industry a steady incentive and a reasona reward.

In exploring the *belt of country referred to under the head*, an approximate profile was constructed extending fr Fredericksburg to Moorfield, exhibiting many of the import features in the structure of the intervening region. The co try on both sides of this line was examined rapidly though w considerable minuteness, excursions for specific objects be made as far as the Potomac on the one hand, and to the rem parts of Culpeper, Rappahannock and Orange counties on other.

The valuable strata of freestone which overlie the prim rocks near the lower end of this line were inspected at vari localities, near Fredericksburg, below this city on the river, a at several points in Stafford county, and it is believed that so

useful views were attained with regard to the geological character of these beds as well as the circumstances under which they furnish the most durable materials for building.

Beyond this to the west, the primary rocks, the slates of the gold region, together with the iron ores occurring in them, and the narrow belt of Talcose limestone which shows itself on the Rapidan, at Mountain run, and other localities were successively observed. The limestone here referred to is a continuation of the narrow belt which appears between Lynchburg and Scottsville on the James river, and is laid bare at various points in Albemarle and Orange. A fragment from the cliff at Mitchell's ford on the Rapidan, yielded in the 100 grains 81.81 grains of carbonate of lime, thus vieing in purity with the limestone of the Valley—and indicating the advantages which might be conferred upon the soil of the neighbouring country by the use of such lime as it would furnish. The iron ore from the site of the old works at Chancellor's, was examined and found to be of good quality.

At a short distance to the west of Germanna ford, commences the region of calcareous shales and sandstones. This, though of considerable breadth, and extending from the Potomac southward through Orange county, and probably with some interruptions, far into North Carolina, constitutes an important feature in our geology to which little or no attention has hitherto been given, these shales and sandstones were traced in Fauquier, Culpeper, Rappahannock, Orange, Prince William and Loudoun counties, and the interesting fact determined that the *Potomac marble* constitutes one of the beds of this series of sedimentary rocks. A calcareous and very mixed conglomerate, similar to that of the Potomac, was found near the eastern flank of the Bull run mountain, continuous with the quarries upon that river. In topographical features and character of the soil, as well as in geological structure, this region bears a striking resemblance to what are called the red shell lands of Pennsylvania and New Jersey. In no district of the state is the connexion between the nature of the prevailing rocks and the qualities of the soil, more strongly marked than here. The red slaty sandstone, containing a considerable amount of carbonate of lime, imparts productive-

ness to the adjacent red soil, while the more siliceous rocks are marked by the sterile character of the fields where they are exposed. In some of the gray micaceous sandstones of a coarse texture, such for example as are seen in the neighbourhood of Cloverland near the base of the Bull run mountain, I discovered visible crystals of carbonate of lime, and found the rock in general to be quite calcareous. Hence the rich growth of clover which adorns the fields, and the luxuriant vegetation which spring up among the debris of the quarries.

A curious feature in the composition of some of these rocks is the presence of the green carbonate and the sulphuret of copper. This fact, which appears to have been observed at a very early period after the settlement of the country, has unhappily kept alive the hope of discovering in these shales veins of a workable copper ore, and has led to repeated enterprises in mining, from which no really profitable result appears ever to have been derived. Most of the openings, either ancient or modern, have disclosed nothing more than a calcareous shale slightly *filmed* with the green carbonate, and making in some cases a superficial show of richness where analysis discovers only an insignificant amount of the enticing mineral.

The specimens of the *sulphuret of copper* found in several places are frequently of a very favourable character, but no indications can be discovered of its being present in sufficient quantity to justify the erection of works for smelting.

In this series of rocks there occurs a blackish slate marked with the impressions of fossil vegetables, and containing much bituminous matter and thin seams or rather films of coal. Similar impressions are abundant also in some of the other associated beds. Indeed, the general aspect of the rock of this district is at first view not unfavourable to the idea that it embodies valuable fields of coal. But while I would by no means assert that seams of this mineral of one or two inches in thickness may not occasionally be found, I *cannot think it probable that any vein of workable extent will ever be discovered among these shales.*

Besides the belt of limestone already referred to as seen on the Rapidan in the line of our section, another narrow ledge is found in Fauquier and Loudoun counties, to the west of Kettoc-

tan and Bull run mountain, and widening as it approaches the Potomac. This rock, which is well adapted to the making of lime, is in some places burnt for that purpose, but it is painful to remark, here as in other places similarly fortunate in position, how little benefit is reaped from the possession of a resource of such high agricultural utility.

In many parts of the Blue Ridge in the neighbourhood of the transverse belt whose general characters I am describing, virgin copper, and the green carbonate have been discovered in thin veins and small masses in the body of quartzose and epidotic rock. In the neighbourhood of Stoney Man, one of the loftiest and wildest of the peaks of this range, near Swift run gap, and at several other points, small specimens have been picked up, and their richness both in the metal and its carbonate have inspired the sanguine with a confident belief of the existence in the bosom of the mountain of treasures of this nature of exhaustless extent. But in regard to all such anticipations it should be borne in mind that the *quantity* is not less important than the *quality* of the ore to stamp it with real value, and that until far more minute and extensive researches in regard to these ores have been made in the localities where they are found than have ever hitherto been attempted, it will be impossible to have any grounds for judging of their extent, and it will be as unwise as hazardous to engage in expensive schemes of mining on their account. Yet I would not have it understood that such researches are to be considered as hopeless or inexpedient. I would rather rejoice to see investigation active, at the same time that in duty to the public interest I would caution against that precipitate and over-sanguine spirit which will not wait for deliberate research—a spirit which in no instance is more likely to terminate in loss and disappointment than when excited by objects of this nature, involved as they must be, even to the diligent scientific explorer, in unavoidable obscurity and doubt.

In the counties of the valley, and in the neighbouring mountains, the researches were of a character deeply interesting to the progress of the survey. After much toil and perplexity, occasioned by the rugged features and complicated structure of the mountainous districts which were examined, the true relations of the

rocks and minerals of this portion of the state were satisfactorily determined. The discovery of a key to the intricate geology of the region west of the valley as connected with that of the valley itself, must be regarded as a result of the highest practical as well as scientific interest. Such a guide having been obtained, the researches in this most difficult field of investigation may be expected to progress with certainty, accuracy and expedition. For this important general result I am largely indebted to the services of my chief assistant, Professor H. D. Rogers, who, connecting the survey of Pennsylvania, of which he has the chief direction, with that of the contiguous portions of our state, has been enabled to throw new and valuable lights upon this and other difficult points in our geology, until now entirely misunderstood.

In connexion with these general investigations, which were indispensable as preliminaries to the minute research essential to the production of a geological map of the Appalachian region, various important observations were made in regard to the limestones, iron ores and coals of the valley and mountains to the west. Numerous specimens of each of these materials have been subjected to chemical examination, and from the mass of results thus obtained valuable light has been shed upon their nature and useful applications in all the varieties of form and composition in which they occur.

A brief statement of some of the geological and chemical results thus far obtained, will serve to illustrate the momentous practical bearings of the investigation in progress in this region, and to display, in a new and gratifying point of view, the vast extent and value of its mineral treasures.

Of the twelve rocks, each marked by certain distinctive characters, composing the mountains and valleys of this region, it has been determined that at least eight are accompanied by beds of iron ore. Each ore has distinctive marks by which it may be recognized, and peculiarities of composition, fitting it for certain uses to which others would be less happily adapted. Thus, in the quantity and variety of this material in all its valuable forms, our state is now proved to have no rival, unless, perhaps Pennsylvania may be such. Looking to the immense extent of the

region over which these rocks are spread, and to the structure of its mountains and valleys—bringing to light at various points each of the twelve principal strata which it comprises—freighted, in great part, with the most inestimable of metallic products, it becomes evident at once that the topography of the rocks and mineral resources of this region, as will be exhibited in the general geological map, is destined to bestow upon it a new and almost unhoped for interest. With such incentives, and with such a guide, enterprise directed to this portion of the state can neither falter or be disappointed. Anticipation confiding in the certain deductions of cautious scientific research already begins to sketch the gladdening picture of successful industry—crowding population and wide-spreading improvement, which at no remote day, it will be its happy lot to realize.

The *coals* of this region were examined at numerous points from the Potomac to the neighbourhood of the Tennessee line, and although much additional investigation is required to ascertain the number and extent of the workable seams of this mineral, enough has already been done to satisfy me that they will, ere long, be regarded as one of the valuable resources of this part of the state. On a former occasion I adverted to the peculiar adaptation of some of these coals in the raw state, to the *manufacture of iron.* The analysis of specimens from several localities, not visited before this season, indicates a composition admirably suited to this use. As examples of coals of this description, I will refer to the three following:

1st. The semi-bituminous coal, from Thom's creek and Strouble's run, in Montgomery county. This consists of

Carbon, - - - - - -	80.20
Bitumen, &c., - - - - -	13.60
Ash, - - - - - -	6.20

The combustible value or calorific power of 100 parts of this coal is equivalent to that of 92.5 parts of carbon.

2d. Semi-bituminous coal from near Lewisburg. This consists of

Carbon, - - - - - -	78.84
Bitumen, &c., - - - - -	14.16
Ash, - - - - - -	7.00

The calorific power of 100 parts of this coal is equivalent to 87 parts of carbon.

3d. Catawba semi-bituminous coal—Botetourt county. This consists of

Carbon, - - - -	78.50
Bitumen, - - -	16.50
Ash, - - - -	5.00

The calorific power of 100 parts of this coal is equivalent to 89.4 parts of carbon.

These and similar results obtained with regard to specimens from other localities in the Appalachian region, illustrate the fitness of these coals for the manufacture of iron, a quality which must be looked upon as giving them incalculable value, when their immediate vicinity to inexhaustible supplies of the ore is taken into the account.

The vast advantages in point of economy resulting from the employment of the *raw coals* of Wales, Scotland and France, in the *smelting of iron ores*, though not unknown in this country, appear as yet to be but imperfectly appreciated. It may therefore be proper to remark, that wherever in Europe, coals of the proper character can be obtained, they are preferred to every other material used for this purpose. It is surely greatly to be desired that a trial were made of our semi-bituminous coals in the smelting furnaces, since by the result of a successful experiment of this kind, if carefully performed, a new impetus would be given to the manufacture of iron in Virginia. At the same time, the importance of applying the hot air blast, especially in connexion with the use of these raw coals, cannot be too urgently insisted upon. The large mass of experience collected of late years in Great Britain, as well as on the continent, conclusively demonstrating the great economy of this process, and the very general disposition in Europe to adopt it wherever practicable, ought to furnish a sufficient inducement for its introduction here; and since, as Berthier has shown, its advantages are augmented by connecting it with the use of raw coals, an especial motive is presented for its adoption in the furnaces of the region of which I am at present treating. Should these improvements be brought into extensive operation, as in process of

time they most assuredly will, the prosperity of this vast and almost forgotten portion of the state, will outstrip any thing that the imagination of its present inhabitants can conceive. What surer foundation for the permanent wealth and power of a community can be found, than the stores of coal and iron embosomed in the rocky strata of its hills and valleys, and what more efficacious stimulus to the mechanic arts, to industry in general, and to the advancement of all practical and profitable knowledge, than the multifarious pursuits linked with the *manufacture of iron?*

Of the limestones of the valley, numerous specimens have been analyzed, with the view of determining the peculiar composition of each variety—a point of much importance in applying them to agricultural or other uses. A sketch of some of the results of this investigation, which is still in progress, may here be fitly introduced. I find that the *carbonate of magnesia* is a much more abundant and common ingredient in these limestones than has hitherto been suspected. All the rocks already tested as hydraulic cements, contain a large proportion of this substance. I have become convinced that a great number of the magnesian limestones of the valley possess the property of hardening under water, and I am at present engaged in extensive experiments upon their qualities in this respect.

The deep blue, almost black limestone of a fine grain and rather smooth fracture, which is commonly burnt for lime, *contains only a slight trace of carbonate of magnesia.*

Its constituents are carbonate of lime, silica, alumina, protoxide of iron, and a trace of carbonate of magnesia, with a little organic matter.

The amount of carbonate of lime usually present in this valuable rock may be seen from the following table of the quantity contained in seven specimens of this description procured in different parts of the valley. A great number of similar results might be added to the table from my minutes, which include the composition of more than thirty specimens, but the seven here given will suffice.

1.	2.	3.	4.	5.	6.	7.
86.3	83.4	85.2	87.5	82.9	83.6	82.8

It appears from this that no great diversity exists in the quality of this rock in different localities. Taking 84 per cent. as the average quantity of carbonate of lime present in this variety, it is easily inferred from the composition of the carbonate, *that each* 100 *lbs. of the rock ought to yield* 47 *lbs. of lime.*

The *dark dun coloured limestone* of very close grain and semi-conchoidal fracture, is even more exempt than the preceding from carbonate of magnesia, and is richer in carbonate of lime. The specimens examined gave an average of 88 per cent. Accordingly, where it has been burnt, this rock has yielded lime of great purity.

The *limestone of a dull grayish blue* colour and of coarse texture, contains a notable portion of *silica and carbonate of magnesia,* and has often the properties of a *hydraulic cement.* The following is the composition of one of several specimens of this variety which were analysed. It was obtained from a hill one mile north of Staunton. One hundred grains contain

Carbonate of lime, - - -	49.50
Carbonate of magnesia, - -	33.87
Silica, - - - -	7.50
Ox. iron and alumina, - -	2.83

The rock of a light grayish blue colour and of very compact texture, almost always contains a large proportion of silica as well as carbonate of magnesia. The hydraulic lime made at Shepherdstown is generally procured from this rock. The following is the composition of a specimen of this kind from Reynolds's quarry. But it is to be observed that even from this neighbourhood the cement rocks exhibit a great diversity in the proportion of their constituents. One hundred grains contain

Carbonate of lime, - - -	32.17
Carbonate of magnesia, - -	18.36
Silica, - - - -	38.93
Ox. iron and alumina, - -	4.17

The rock to be used in preparing cement for the locks of the James river canal is of this kind. It is obtained in Rockbridge county, and contains

Carbonate of lime, - - -	38.33
Carbonate of magnesia, -	16.30
Silica, - - - -	36.60
Ox. iron and alumina, - -	6.33

It will appear, from what has been stated in regard to the aspect of the several varieties of limestone above described, that any careful observer may in general distinguish between those rocks which are magnesian or siliceous and those which are not, a matter of no small importance, in the employment of lime in agriculture, as a cement, or for other uses.

The great abundance of the dark blue limestone, so admirably suited to the uses of the farmer, holds out a strong inducement to the employment of lime upon the soil. In my former report I attempted to remove the mistaken impression, that the land of limestone regions is already sufficiently imbued with calcareous matter, by appealing to the results of analysis; and I would now repeat the observations then made, as having been confirmed by further examination.

There cannot be any fact in practical agriculture more clearly proved than the beneficial action of lime upon the soil of limestone regions, such as our valley. Why then is it not extensively used by the farmers in that portion of the state? With so sure and inexhaustible a means of improvement, (every where around them) every hill and valley might be made productive. This is one day to be the result of the systematic and general use of lime, aided by an improved scheme of agriculture. But I would gladly speed the progress of amelioration, by pointing to the invaluable resource which nature has provided for the improvement of this country, and by expostulating earnestly, on grounds of science and experience, with those who are disposed to neglect the boon.

The reconnoissance of the *south-western counties* embraced a rapid examination of parts of Grayson, Wythe, Montgomery, Smyth and Russell, and included a more detailed investigation of the lead, plaister and salt of this region.

The *lead mines* are situated near Cripple creek, about four miles from Poplar camp furnace, in a direction a little south of west. They are within half a mile of the south bank of New

river, and about one and a half from the base of the Poplar camp or Iron mountain. The ore occurs in a siliceous limestone generally of a white or gray colour, though sometimes blue. The veins are irregular in dip and direction, frequently turning very abruptly, and sending off leads or branches. On either side of the ore, the enclosing material continues of a soft texture as far as the walls of limestone enclosing the whole, which vary in their distance from each other. On the upper side of the vein is generally found a reddish clay. On the lower side is a firmer material containing crystals of phosphate of lead and other matters. This the workmen here as in Europe call clinker, and they reject it as of no value.

The vein proper is in general twelve inches thick, and contains the following ores of lead:

1. Compact sulphuret or blue ore.
2. Compact carbonate or gray ore.
3. Crystallized carbonate—or Cat's tooth.
4. Mixture of carbonate and oxide—brown and red ore.
5. Finely divided sulphuret—black ore.

The sulphuret or blue ore occurs only in some parts of the vein in irregular masses or cups as they are called, and does not occupy one half of the productive portion of the vein. The other ores occur along side of it and are mingled with it. The adjacent limestone is sometimes in a soft and crumbly condition, and curiously spotted—sometimes in the form of a beautiful white spar containing crystals of cubical galena.

There are six openings at present wrought, each having drifts below the surface at various depths from 30 to 120 feet. These are all comprised within a space of less than 150 yards square. To the S. W. are numerous pits from which ore was extracted in former years. The entire distance through which the lead has been traced and wrought in this vicinity is about half a mile. The general direction of the veins is nearly N. E. and S. W. One of the same description has been found at several points to the N. E., and among others at Mr. Sawyer's, on Reed creek, about 7 miles from the mines. Blue ore has also been found in small quantity on Mr. Graham's land, at an equal distance, in a due north direction. Whether a valuable amount of the ore

exists at either of these places, or in any of the numerous localities in other and distant parts of the valley in which specimens have been discovered, it is impossible to say without much further investigation.

The extent of the workable ore, at the mines just described, appears from the indications observed, to be very considerable, and it were greatly to be desired that a systematic mining of these veins were undertaken upon a scale commensurate with their value. At present a wasteful method of excavation is threatening serious injury to the interests of future mining operations in this region, and, if persevered in, will destroy the usefulness of many portions of the veins now worked by rendering them almost inaccessible or incapable of being farther wrought.

In the operation of washing at what are called the Buddles, though conducted more judiciously than the mining—there is evidently a larger proportion of useful material carried off than ought to be allowed to escape. This fact I ascertained by an examination of the ochreous earth deposited by the stream at some distance below the Buddles.

The position of the veins in a hill near the south bank of the New river makes it obvious that a tunnel driven through the base of the hill into the veins, would afford great facility to the operations under ground, whilst it would open up a great extent of the ore and would dispense with the expensive and inefficient process of raising the ore in buckets. By locating the Buddles and the furnaces at the mouth of such an adit, a combination of advantages would be secured: It is estimated that 25 per cent. of the material as it is procured in the crude state from the mines, is removed by washing at the Buddles, and that 100 lbs. of the rough or 75 of the washed ore will yield 50 lbs. of metal. A result so very high ought to invite attention to this interesting region, especially when it is considered that this is the only available body of lead ore in any of the Atlantic states.

The fact that by far the larger portion of the lead which these mines furnish is carried in wagons to Baltimore, is a striking proof of the lucrative nature of the manufacture, and strongly indicates the benefit which in reference to this product, the public may be expected to reap from the extensive works of improve-

ments which have been so wisely projected in this portion of the state.

The *Plaister banks*, in the North Holston and Walker's creek valleys, are another of the gifts which liberal Nature has bestowed upon this favoured region. The geological structure of the valley of the Holston is fraught with peculiar interest. After descending the northern slope of Walker's mountain, we come in view of the lofty limestone hills forming the southern boundary of the valley, and taking our station upon some elevated knoll, we see spread out before us a scene of singular variety and beauty. Hills of limestone apparently arranged in rows, presenting conical and rounded outlines of surprising symmetry and elegance, are stationed along the valley at nearly equal intervals. The rich verdure that spreads to their very summits, darkened by the thick foliage of the sugar trees growing on their steep sides, softens the picturesque wildness of the landscape and conveys the idea of a soil of exuberant fertility. In the three first ranges of these hills the southern dip of the rocks in Walker's mountain and the intervening country is preserved, but nearer to the river the limestones are seen dipping in the opposite direction. The anticlinal axis marked as occurring in a black slate is in the immediate vicinity of the plaister banks and the wells from which the brine is obtained. This axis extends far to the east and west, and constitutes an important feature in the geology of this region. The plaster has been found along this valley and in that of Walker's creek which joins it to the coast, for a distance of about 40 miles. Whether it extends in the latter direction beyond the termination of this line cannot as yet be known,—but even should it not surpass this limit, the value of the deposit would baffle calculation. It does not occur as is sometimes supposed like the other rocks of the country, in a regular stratum having a fixed relation to the rest, but in masses of irregular form imbedded in dark-coloured or ochreous clays. These masses are often of enormous magnitude, and are either partially exposed at the surface, or covered with a variable depth of earth. The excavation at M'Call's quarry, which is nearly all in solid gypsum, is about 25 feet deep, 50 feet long, and 15 wide, and from borings it would appear that

this solid mass of gypsum is more than 100 feet in depth. In the neighbourhood of Buchanan's banks in the valley of Walker's creek, extensive exposures of it occur upon the surface, but no very large excavations have yet been made. Small openings have been made at various other points, and though the plaister has always been found in great abundance, the want of capital has prevented extensive operations from being attempted.

Some idea may be formed of the immense amount of gypsum contained in these valleys, from the fact that in the borings for salt water which have been frequently made near the Holston, fragments of this rock have been brought up from the depth of 700 feet. Indeed, there seems to be every reason for believing that it extends to great depths throughout a large portion of the region in which it is found—sometimes in masses of enormous dimensions, and sometimes in small fragments and thin beds, mingled with ochreous clays and decomposed pyritous slate.

In speculating upon the origin of the gypsum of this region, the readiest explanation that suggests itself is that which ascribes its production to similar causes with those which gave birth to the gypsum of the Tertiary strata of lower Virginia. It has been incidentally remarked above, that *pyritous slate* occurs in fragments mingled with the gypsum and clay at the salt wells and other places. Supposing the valley to have once been filled with the debris of this slate and of the neighbouring limestones, we would have all the materials brought together which are necessary for the production of the gypsum, while the slate after decomposition would become the clayey matrix in which the crystals would collect. This view is rendered more probable from the occurrence, even in the midst of the solid masses of plaister, of fragments of the siliceous rock which skirts the valley on the south. It is at least certain that the gypsum has not been deposited here as in some other parts of the world, from the waters of Thermal springs holding it in solution, since in that case it would be found disposed in layers as travertin, and not in the irregular and scattered condition which has been described.

The *Brine springs* constitute another valuable and interesting feature in the geology of the Holston valley. Of the stratum

from which the salt water is derived nothing certain is thus far known, although speculations have not been wanting on the subject. By some it has been imagined that salt in the solid form exists at a great depth below the level of the wells; and this idea has been countenanced by the fact, affirmed by many, that granules of rock salt are sometimes seen in the water as it is pumped up. On this point, however, it may be remarked that these granules might have existed dispersed through the mass of a saliferous sandstone, as is the case in some other parts of the world. Be this as it may, the borings and wells have never penetrated to a stratum such as is usually the repository of the salt water, but have gone through successive beds of blue and red clay and broken slate, all of them mingled more or less with plaister. The two wells now in use, King's and Preston's, are each 212 feet deep. They are very near each other, and are thought to communicate beneath, and are situated a little to the south of the anticlinal line before noticed. The water, raised by a steam engine, is conveyed in wooden pipes to the furnace, two miles distant, where, after the crude impurities have been suffered to subside, by allowing it to rest some time in large tanks or reservoirs, it is transferred to the kettles. Of these there are five double rows, each containing 100 kettles, making in all 500. 30,000 gallons of the brine are daily boiled down, yielding an average product of 1,000 bushels of salt, or one bushel for each 30 gallons. The sulphate of lime, which is almost the only impurity in this brine, for the most part adheres to the bottom of the kettles, and leaves the salt in a state of remarkable purity. At the same time sulphurets are formed by the intense heat, which give a peculiar odour and flavour to the residual mass. No muriates of lime or magnesia exist in this brine. Hence it is free from *bittern*, and dries rapidly in the air.

In the strength of the brine as well as its freedom from troublesome impurities, these wells are scarcely excelled by any in the world.

While all the salt manufactured here is of a very excellent quality, there are three grades, distinguished by different degrees of purity. These are,

1. The common salt, which is of a fine grain, dry, and not liable to deliquesce in moist air, but is a little discoloured.
2. The table salt, which is beautifully white and fine. This is made by very rapid boiling.
3. The alum salt, perfectly pure, in thin crystals of a satin lustre. This is formed by a slow crystallization as the kettles cool.

Looking to the alum salt now made in Kanawha, and the table salt above described, Virginia has just reason to be proud of the pre-eminence she has attained in this branch of manufacture.

Feeling deeply interested that the work, committed to my superintendence, may progress with all the speed compatible with minute accuracy both in regard to practical details and scientific deductions, I have endeavoured to form an estimate of the shortest period within which it appears practicable to complete it, with the provisions of the act passed by the last legislature. The complex and more precise experience of the intricacies of our geology, acquired during the last season's researches has led to a full conviction that with the present force it will not be practicable to bring the survey to a termination in a less time than twelve years; that is, without sacrificing that exactness in research which must form its leading claim to confidence, and confer upon it all its utility.

Early in the season it became apparent that further assistance was required, both in the laboratory and field, and accordingly at my own cost and responsibility another aid was engaged, whose labours in both departments contributed much to the advancement of the work. So that in fact the amount of duty, performed during the season, largely exceeded what could have been executed by the assistants authorised by the bill.

During the whole period of field work, the utmost activity has been exerted by all engaged in the task, and scarcely any suspension of labour has been permitted on account of rain and other unfavourable conditions of the weather. For nine months

the chemical investigations connected with the survey have been steadily progressing, occupying my own attention daily, and giving employment to one of my assistants during a considerable part of the time.

Looking to the amount of work executed during the past season, both in the way of preliminary observation and detailed research, and guided by the knowledge, now obtained, of the extent of labour requisite for the completion of the survey, with a view to the accurate delineation of the geological details upon the map of the state, as well as the other important objects for which it was set on foot, I cannot hope, without a large addition to the corps of assistants, to progress with greater rapidity than during the past year.

But it is unnecessary to remark that so tedious a prosecution of the work, and so long a postponement of the most valuable and interesting results which can only be properly made public at the conclusion of the survey, could not fail to prove injurious to the enterprise by diminishing the confidence of the public in the competency and activity of those employed.

In requesting of the legislature *an augmentation of the annual appropriation for the work*, it should be distinctly borne in mind, that by such an addition *the total expense of the survey, instead of being increased, would be considerably lessened.* Where several explorers can give their attention to the same formations in contiguous districts, each has the advantage, under a systematic combination of efforts, of being directed in his inquiries by the collective experience of the whole, and thus the investigations of each will be conducted with increased accuracy and expedition.

Another weighty inducement for adding to the number of the assistants to the survey arises from the expediency of making known as early as possible the resources which it will develope —a consideration at no time more important than at present, when the mineral possessions of the state are attracting the enterprise and the capital of the community, and when plans of public improvement of great magnitude, to the success of which

the survey must be more or less auxiliary, are enlisting general interest.

But besides this provision for an addition to the number of assistants, an increase will be required of that part of the appropriation set apart as a fund for the contingent expenses incurred in the operations of the field and laboratory. Among the larger items demanding such a provision, may be instanced the expense of exploring the rivers, creeks and inlets of the marl region by a boat properly constructed and equipped for the service, and of the transportation by an appropriate vehicle of the specimens collected in the numerous and distant localities examined; and I may add the expense incurred for the apparatus and agents required in the chemical department of the survey.

It is conceived that the exigencies of the survey will be fully met by an appropriation which will furnish two additional salaries for assistants, and an increase of one thousand dollars to the portion of the fund destined for the contingent expenses. With the means of prosecuting the work thus enlarged, it is readily demonstrated from the experience already acquired of the advantages of combined exertion in the field, that the work may be brought to a termination in one half the time necessary for its completion under the organization at present provided by law. Thus, while we assume twelve years for the time necessary with the means now at command, the entire expense of the survey will be about 60,000 dollars, whereas, with the ampler provisions above specified, it will probably fall short of 50,000.

Should the legislature accede to my views, and augment to this extent the annual appropriation, it will not exceed that contemplated for the survey of the much smaller state of Pennsylvania, while it will be considerably less than one half of the sum devoted by New York to a territory of less extent, less intricacy of structure, and less variety and fertility of mineral productions. I may be permitted to add, that in both of these states a separate assistant is furnished for the chemical department, though this aid it is not my intention to request.

There are other inducements to recommend the course here proposed, which, though less weighty than those just presented,

are not wanting in importance when it is considered that the reputation of our state for patriotism and love of science is not without an interest in the progress and results of the survey. Impressed with the magnitude of the undertaking, it may not be unbecoming in me to remark that men of science in this country and abroad are looking forward to its completion with interest and curiosity. The responsibility thus incurred as the scientific investigator of the yet almost unexplored geology of our state, renders me still more desirous of obtaining such facilities for the execution of the work as will enable me to complete the numerous difficult researches, which it involves, ere the more interesting results can be anticipated by similar researches in some of the other states; and it increases my anxiety to execute the task in a style of accuracy and minuteness, which, while it secures *the permanent* utility of the work, may, I hope, do credit to Virgina, advancing as she is in reputation for the encouragement of education and science.

SECOND

REPORT

OF THE PROGRESS OF

THE GEOLOGICAL SURVEY

OF THE

STATE OF VIRGINIA,

FOR THE

YEAR 1837.

BY WILLIAM B. ROGERS,

PROFESSOR OF NATURAL PHILOSOPHY IN THE UNIVERSITY OF VIRGINIA.

Office of the Board of Public Works, 10*th Feb.* 1838.

Sir,

Inclosed is a communication to the House of Delegates, which you will be pleased to lay before that body.

Very respectfully,

Your most obedient servant,

DAVID CAMPBELL,

President of the Board of Public Works.

To the Honourable the Speaker of the House of Delegates.

Office of the Board of Public Works, 10*th Feb.* 1838.

To the House of Delegates.

I have the honour to transmit to the House of Delegates a report of the chief geologist of the state, detailing the progress of the geological survey in the year 1837.

DAVID CAMPBELL,

President of the Board of Public Works.

REPORT.

In pursuance of the law requiring the principal geologist of the state, annually to submit to the board of public works an account of the progress of the geological survey, I beg leave to make the following report:

The board are already aware of the unavoidable delay which occurred in completing the organization of the survey in the early part of the season; a delay which as they know was occasioned by the difficulty of procuring suitable assistants to fill the vacancies existing in the corps and to increase the number of my aids as authorized by the law passed at the last session of the legislature, enlarging the appropriation devoted to the survey. Notwithstanding these impediments, however, active explorations were commenced by one division of my assistants in the tide water district of the state about the middle of April; and early in June, our whole force was transferred to the region west of the Blue Ridge as the theatre of operations for the remainder of the season.

While thus alluding generally to the labours of the survey, I trust it will not be thought inappropriate to bear my cordial testimony to the zeal and efficiency with which my assistants have executed the tasks respectively allotted to them, and to express the high gratification inspired by their laborious and careful investigations. I would also take this occasion of tendering to the board my warmest acknowledgments for the interest they have manifested in the progress of the work, and for their prompt co-operation in all suggestions calculated to promote its success.

Adopting the method of exploration referred to in my report of last year, the investigations in the tide water district have for the most part been conducted by means of a boat suitably fitted up and manned.

Aided by these facilities, the assistant to whom this department of duty was allotted, Mr. Charles B. Hayden, was enabled to proceed with satisfactory minuteness in the examination of the shores of the James river and its tributaries, from its mouth as far up as the head of tide, inspecting the exposures of marl, clay, or other materials of interest presented on the banks of the main stream on the rivers, creeks and inlets connected with it, at the same time, collecting specimens for chemical analysis, or such other examination as might be required. Occasional examinations were also made at various points removed from the water, either with the view of ascertaining the continuity of deposits, or of obviating the necessity of future exploration from the land side, where such examination might be rendered difficult by the peculiar position of the locality.

Among the general objects of useful interest accomplished by the researches here referred to, may be mentioned a more precise determination than had hitherto been effected of the breadth of the Eocene, or green sand marl, where it is intersected by the James river, and the demonstration that no beds of secondary green sand, similar to those of New Jersey, are interposed between the Eocene and the coarse conglomerates, sandstones and clays which overlie the primary rocks near the lower falls of the James river, of the existence of which, writers at a distance have more than once stated that some evidences had been discovered. On this head, I have now no hesitation in affirming that the concurring testimony of observations made in the course of the survey, on the Potomac, Rappahannock, Mattapony, Pamunkey and James rivers, is conclusive against the existence within the region traversed by these streams of the New Jersey secondary, or any equivalent formation.

Of the numerous specimens of marls, &c. collected in the course of this investigation, many have since been chemically examined, and the rest are now in the course of analysis. A table of the composition of these and various other marls, examined within the last eighteen months, is herewith presented, under the belief that although not strictly required in the annual report of the progress of the survey, such details are likely to prove use-

ful to individuals interested in knowing the value of their marls, and are not of a nature to render it important that they should be reserved for the final report.

The exposures of marl upon the James river, though in some instances extending continuously for miles along the shore, are by no means commensurate with the deposits found at some distance in the interior. Low grounds, and banks of comparatively little altitude, occupy a large portion of either shore, for the most part filling up spaces whence the original deposit has been removed by denuding action, and rarely presenting any remains of the calcareous material, while along the banks of the minor streams, and on the declivities of the hills overlooking the lower levels, ample stores of this invaluable deposit are generally discovered. Nansemond river, Pagan creek and its branches, Lawn's creek, Chipoaks, Archershape, &c. on all of which nearly uninterrupted exposures of the marl occur, illustrate the truth of this remark, and a similar observation is applicable to the shores of our other principal rivers and their tributaries.

Of the advantages of exploring our tide water rivers by means of boats, the experience of the past season has furnished satisfactory proof, and in view of the facilities thus proffered to our future researches, by a suitable co-operation of inland and aquatic investigations, I indulge the hope of bringing to a speedy completion that portion of the exploring duties of the survey which relates to the lower district of the state.

MIOCENE MARLS.

Localities.	*Observations.*	*Carb. Lime.*
LANCASTER.		
Capt. Ja's. Robinson's,	Small fragments of shell in a ferruginous sand—green sand a trace,	42.0
Do.	Ditto, ditto,	37.5
Mr. Yerley's	Ditto, Ditto, rather compact,	30.6
Do.	Yellow—aluminous—green sand a trace,	12.2
Do.	Yellow—consisting of shelly fragments partially cemented—green sand a trace,	21.0
Mr. Cabell's,	Shells decomposed and partially cemented,	42.0
Do.	Ditto,	46.5

Localities.	*Observations.*	*Carb. Lime.*
Mr. Callahan's,	Yellow—fragments of shell in ferruginous sand—large grains of green sand in considerable quantity,	21.5
Mrs. Palmer's,	Yellow—small shells and fragments—green sand a trace,	32.9
Benj. Walker's,	Blue—green sand a trace,	18.0
Warner George's,	Blue—shelly fragments—green sand a trace,	14.7
Col. Palmer's,	Light—conglomerated fragments of shell—slightly compact—green sand a trace,	57.0
Do.	Shells decomposed and partially cemented,	37.5
Dr. Jones's,	Ditto, porous,	86.8
Union Mills,	Yellow—small shells in ferruginous sand,	23.8
Do.	Light—quite compact—shells small—green sand a trace,	62.5
Col. Phil. Branam's,	Blue—tenacious—small shells—green sand a trace,	21.5
Mr. S. Downing's,	Bluish—10 or 12 per cent. of green sand,	17.0
Braxton Tomlin's,	Light—shelly fragments—green sand a trace,	32.9
S. Downing's,	No. (4)—White—compact, with impressions of shells, containing pebbles—specked with green sand,	67.4
Williamson Tomlin's,	Blue—with small shells—green sand a trace,	23.8
WESTMORELAND.		
Strafford Cliff's,	Blue—partially—cemented—green sand a trace,	44.3
RICHMOND.		
R. O. Jeffries's,	Blue—with small bivalve shells,	27.7
Wm. Bernard's,	Blue—with decomposed fragments of shells,	12.5
Mr. Saunder's,	Very compact—quite perceptibly specked with green sand—very little shelly matter,	9.0
NORTHUMBERLAND.		
John Fulks's,	Light blue—small fragments of shell,	17.0
Walter Rice's,	Very ferruginous and compact—with fragments of shell—specked with green sand,	6.8
Mr. Hedley's,	Yellow—green sand a trace,	21.5
KING GEORGE.		
Mill on Machadox run,	Blue—a little green sand,	17.0

Localities.	*Observations.*	*Carb. Lime.*
MATHEWS.		
A. Braxton's - -	Shells conglomerated—occasionally crystallized—light, - - - -	48.8
Warehouse Creek, -	Compact and semi-crystalline—ferruginous,	87.5
MIDDLESEX.		
Doctor Rowan's, - -	No. (1)—Light—containing small fragments of shell, - - - -	39.7
Do. - -	No. (2)—consisting of small bivalve shells—green sand a trace, - - -	48.8
Prospect Hill Creek Shore,	Composed entirely of small shells intermixed with sand—green sand a trace - -	38.5
D. Oaks's, - -	No. (1)—White—in small nodules—green sand a trace, - - - -	78.4
Do. - - -	No. (2) Ditto, - - -	69.3
Do. - - -	No. (3) Ditto, - - -	76.1
Do. - - -	Ditto, - - -	75.0
Do. - - -	Ditto, - - -	73.8
Capt. Hailey's, - -	Light—containing fragments of shell—a little green sand, - - -	26.1
C. Braxton's, - -	White—shells decomposed—green sand a trace, - - - - -	64.7
Do. - - -	Shells less decomposed and slightly cemented,	67.0
Do. - - -	ditto, - - -	87.0
Col. Blaky's, - -	White—decomposed shells and fragments cemented, - - - -	82.9
GLOUCESTER.		
Mr. Pointer's, - -	Yellow—clayey—containing a good many ostreas, - - - - -	50.0
Roberts's Mill, - -	Upper stratum—containing fragments of shells, - - - - -	34.0
Gloucester Town, - -	Shells decomposed and slightly cemented, -	40.9
Mr. Billups's, - -	White—shells decomposed—green sand a trace, - - - - -	37.5
Mr. Thruston's, - -	Shells decomposed and slightly cemented, -	60.2
Mr. R. Persill's, - -	Fragments of shell cemented—green sand a trace, - - - - -	71.5
Robins's Mill, - -	Blue—tenacious—shells decomposed—green sand a trace, - - - -	39.7
Jones's Mill, - -	Upper stratum—white—shells very much decomposed and slightly cemented, -	51.1
Mr. Beverage's, - -	Shells much broken—a good many partially decomposed chamas—green sand a trace,	57.9

Localities.	*Observations.*	*Carb. Lime.*
Hill near Robins's Mill, -	Consisting chiefly of broken fragments of shell, - - - - - -	30.6
Mr. Beverage's, - -	Small fragments of shell—greenish—green sand a trace, - - - - -	42.0
Gloucester Town, - -	Do. richly specked with green sand,	41.5
F. Oliver's, - -	Do. green sand a trace, - -	73.6
From the Road between Gloucester Court-house and Gloucester Town, -	In nodules, - - - - -	51.1
Court-house Creek Bridge,	Fragments of shell with sand intermixed, -	46.5
Mr. Billups's, - -	White—decomposed and partially cemented —green sand a trace, - - -	51.1
King & Queen.		
Piedmont, - -	Blue—containing fragments of shell—green sand a trace, - - - -	33.6
Do. lower bank, -	Blue Ditto, Ditto, - -	22.2
Mr. Bagby's, - -	White—shells finely decomposed and partially cemented, - - - - -	80.6
Do. - - -	Blue—containing fragments of shell, -	30.6
Mr. Mann's, - -	Light—nodular, - - - - -	78.4
Do. - - -	White—containing small fragments of shell,	80.6
Mr. Burton's, - -	Light—shells decomposed—occasionally cemented, - - - - - -	85.2
Mr. Atkins's, - -	Small fragments of shell, - - -	76.1
Mr. Ryland's, - -	Shells decomposed, - - -	46.5
Mr. Motley's, - -	Blue—small shells and fragments—green sand a trace, - - - -	14.7
Mr. Pollard's, - -	Blue—fragments of shell—green sand a trace, - - - - -	21.5
Mr. Gresham's, - -	Light—fragments and decomposed shell slightly cemented, - - -	82.9
Mr. Duval's, - -	Bluish—small fragments of shell principally of the chama—green sand a trace,	73.7
King William.		
Robert Hill's, - -	Light—shells decomposed and very slightly cemented, - - - - -	54.5
Do. - - -	Light—shells decomposed and slightly compact, - - - - - -	68.4
Do. - - -	Large fragments of shell in blue sand—green sand a trace, - - -	12.5
Mr. Edwards's, - -	Light—decomposed shells and fragments, -	76.1
Mr. Ellet's, - -	Blue—containing fragments of shell, -	7.9

Localities.	*Observations.*	*Carb. Lime.*
Mr. Ellet's,	Light—tenacious—containing perfect shells and fragments,	26.3
Scotland Banks,	Blue—containing fragments of shell,	7.9
Mr. Neal's,	Fragments of shell intermixed with sand—green sand a trace,	21.5
Do.	Ditto, Ditto, Ditto,	14.0
ESSEX.		
Dr. Minor's,	Blue—rather compact—containing fragments of shell and small pebbles,	56.8
Mr. Hunter's,	Ditto,	17.0
Dr. Minor's,	Ditto, green sand a trace,	14.7
Mr. Bernard's,	Ditto,	34.5
ISLE OF WIGHT.		
Mr. H. Day's,	Perfect shells and fragments—sometimes cemented—green sand a trace,	76.1
Do.	Ferruginous rock marl—semi-crystalline—green sand a trace,	77.2
Mr. Saunders's,	(2d stratum)—yellow—small friable fragments of shell—considerable green sand,	48.8
Do.	(3d stratum) Ditto,	60.2
Do.	Ditto,	42.0
James Pedin's,	Light—shells entirely decomposed—nodular—green sand a trace,	54.5
Day's Point,	Blue—friable—micaceous and sandy,	7.9
G. Purdie's,	Shells and fragments in a light tenacious clay—frequently rich in indurated casts of the chama—green sand a trace—sometimes a fragmentary conglomerate,	71.5
Do.	Ditto,	62.5
Do.	Conglomerate, Ditto,	81.8
Do.	Ditto,	63.6
Mr. White's,	A conglomerate of perfect shells and fragments—ferruginous and semi-crystalline—very compact,	91.3
Mr. S. P. Jourdan's,	Very comminuted fragments of shell in a ferruginous sand—green sand a trace,	53.4
Do.	Ditto,	79.5
Merit Todd's,	Light—rather tenacious—shells decomposed green sand a trace,	28.4
Do.	A conglomerate of small shells and fragments, intermixed with a ferruginous sand—tinged with green sand,	42.0
Rocks,	Blue—arenaceous—very friable—containing a few small cythereas,	7.95

Localities.	*Observations.*	*Carb. Lime.*
Do.	A coarse shelly conglomerate—yellow—occasionally a cast of the chama,	78.4
Mr. Booth's,	Of a very light yellow colour—containing small fragments—frequently cemented,	64.7
Do.	Shells decomposed—concretionary,	71.5
John Y. Mason's,	Small cythereas in a yellow sand, with a few other shells and fragments—green sand a trace,	35.2
NANSEMOND.		
Town Point,	Ferruginous—consisting of small shells and fragments,	67.5
2 miles above Town Point,	Ferruginous—consisting of small shells and fragments,	52.3
Mr. Keeling's,	Small shells and fragments in a light sand—also fragments of the pecten—sometimes conglomerated,	75.0
Do.	More ferruginous—containing fewer shells,	30.6
Below Dumpling Island,	A conglomerate of fragments—quite compact,	85.2
Do.	Finely comminuted shelly matter—deeply tinged with iron,	71.5
Mr. Cowper's,	Ferruginous—consisting chiefly of fine fragments,	72.7
Near Suffolk,	Ditto, ditto, green sand a trace,	17.0
Upper shore of Nansemond river (near the mouth,)	Small fragments of shell, with perfect shells intermixed—ferruginous,	82.9
Point above Sleepy Hole ferry,	Principally chamas and crepidulas, intermixed with yellow sand,	43.2
Near Suffolk,	Blue—containing finely divided shelly matter,	22.7
Upper shore (near Sleepy Hole ferry,)	Blue—containing fine and coarse fragments of small shells,	30.6
Col. Corbell's,	Small fragments of shell—ferruginous,	62.5
Do.	Ditto,	76.2
Maj. Crocker's,	Ditto,	64.7
Do.	Ditto,	28.0
W. H. Goodwin's,	Ditto,	53.4
Mr. Phillip's,	Ditto,	80.6
Near Chucatuck mill,	Ditto,	82.9

Localities.	*Observations.*	*Carb. Lime.*
ELIZABETH CITY.		
Hampton, - - -	Ferruginous—fragments of shells with perfect shells intermixed, - - -	71.5
Do. - - - -	Ditto, -	25.0
SURRY.		
Mrs. Faulcon's, - -	Yellow—consisting of decomposed shells and fragments—occasionally slightly cemented, - - - - -	64.5
3 or 4 miles above Four Mile tree, - - -	Fragments of a shell in white sand—slightly intermixed with green sand, - -	47.2
Do. - - -	A yellow conglomerate of shells and casts,	78.40
Near Four Mile tree, -	Fragments of shells and undecomposed shells, - - - - - -	88.6
Mr. Organ's—Clermont, -	Yellowish white—fine and friable—occasionally concretionary, - - -	71.5
Wakefield, - - -	Light—shells generally decomposed—a few fragments in a white sand—green sand a trace, - - - - - -	51.1
Do. - - -	Bluish—shells very much decomposed, -	75.0
Douglas's, - - -	White indurated casts of chamas, - -	87.5
Clermont (river shore,) -	Blue—largely intermixed with green sand—shells finely decomposed, - -	10.2
Upper Chipoke creek, -	A calcareo-siliceous conglomerate—very compact—containing fragments of pectens and casts of pernas, - -	55.6
Stithes, - - - -	Small fragments of shell in sand—a good many chamas—quite richly specked with green sand, - - - - -	42.0
Do. - - - - -	Ditto, - - -	33.0
River shore (above the mouth of College creek,)	Consisting of fragments of the chama in a light sand, - - - - -	144.3
A. C. Jones's, - -	Shells and fragments in a light sand—intermixed with green sand, - -	53.2
PRINCE GEORGE.		
Coggin's Point, - -	Small shells and fragments in a yellow sand—green sand a trace - - -	28.4
Mr. Prentice's, - -	A great variety of shells in sand, - -	53.6
Evergreen, - - -	Fragments of shells in a light sand, -	32.9
Tarbay, - - -	Ditto, ditto, - -	19.4

Localities.	*Observations.*	*Carb. Lime.*
JAMES CITY.		
King's Mill, - - -	Chiefly fragments of the chama—intermixed with green sand, - - -	56.8
WARWICK.		
Mr. Wynn's, - - -	- - - - - - -	75.0

EOCENE MARLS.

CHARLES CITY.		
Herring Creek, - -	Light shells—generally decomposed—slightly compact—intermixed with green sand,	87.5
Do. - - -	Ditto, - - - -	50.0
Do. - - -	Ditto, - - - -	50.0
PRINCE GEORGE.		
Coggin's Point, - -	Yellow—friable—no traces of shells—a little green sand, - - -	64.7
Do. - - -	Ditto, - - -	37.5
Maycox, - - -	Yellow—no traces of shells—in nodules—siliceous, - - - -	42.2
Do. - - - -	Light—compact—containing impressions of shells intermixed with green sand, -	73.8
Do. - - - -	(Mouth of Powell's creek, ditto, -	42.0
CHESTERFIELD.		
Mrs. Cocks's, - - -	Indurated—containing impressions of shells and small decomposed shells intermixed with green sand, - - -	60.2
Do. - - -	Ditto, - - -	76.1
HENRICO.		
Mr. Organ's, - - -	(Upper plantation,)—light—fine and friable—but slight traces of shells—a little green sand, - - - -	47.2
Deep Bottom, - - -	Light yellow—indurated—homogeneous—containing casts of shells—slightly micaceous, - - - - -	54.5

The scene of exploration in the upper portion of the State where the entire force of the corps was actively engaged, from June until late in the autumn, embraced all the region lying be-

tween the Blue Ridge and the first escarpment of the coal-bearing rocks of the Alleghany proper. Dividing this extensive field into three portions, by convenient transverse lines, an assistant, with such equipments as were thought necessary, was allotted to each district; Mr. Charles B. Hayden being placed in the northern, Professor J. B. Rogers in the middle, and Professor W. E. Eaken in the southern subdivision. Pursuing a common system of investigation in all the districts, we commenced our inquiries by numerous observations along the western declivity and flank of the Blue Ridge, chiefly with the view of conclusively determining the relation of the rocks of that mountain and of the valley to the west, a problem of some difficulty, and of which our previous exploration had not furnished a satisfactory explanation. Next, by a series of transverse lines, extending from the Blue Ridge across the valley, and numerous ranges of mountains further west, we proceeded to ascertain with more precision than had yet been done, the law of succession of the various rocks composing this wide belt of country, noting their dip, arrangement, character and mineral contents at every step, and tracing geological profiles of our route. In this portion of our labour I may be allowed to state, that the fatigue and privation to which we were frequently exposed in our travels, among rugged mountains, and by unfrequented and sometimes almost pathless routes, were not a little lightened by the animating influence of scenery, at once wild and beautiful and sublime, rich in subjects for the artist's pencil, and pregnant with lessons for the geological inquirer.

Guided by the precise knowledge thus attained, of the general structure of the regions we proposed to investigate, we entered upon the detailed examinations necessary to a proper developement of the mineral resources of each district, and to the introduction of geological delineations on the state map.

Following the longitudinal bearings of all the strata, tracing them through the valley or along the flanks and summits of the mountains, marking their boundaries and their changes of extent and structure, and carefully pursuing every indication pointing to useful economical results, we have been enabled, through

the active labours of this season, to accumulate a large body of accurate and valuable details, illustrating the resources as well as the geological structure of extensive portions of the region in which our inquiries were pursued. Indeed, such has been the success of the plan of investigation adopted, that but for numerour errors of the state map, of which we have had glaring and sometimes ludicrous illustrations in the course of the season, I would feel myself prepared to give a visible form to our results by a systematic geological colouring of many of the counties, both of the northern and middle, as well as important portions of the southern district.

From the vast extent of the region in question, the intricacies of geological structure occurring in many parts of it, and the natural obstacles to exploration arising from the singularly rugged topography of its mountainous portions, it will at once be seen that, with the force at our command, the labours of a single season, however active and judiciously bestowed, could accomplish but a part, and that by no means the larger portion of the researches requisite for a minute knowledge of its structure, and its peculiarly valuable mineral contents.

Aware, as the board must be, of the nature and extent of the impediments referred to, they will be enabled better to appreciate their influence upon the progress of our researches, from the consideration that in geological explorations, conducted in such a region, satisfactory results are rarely to be attained merely by the investigation of exposures occurring along a highway, or in positions equally easy to be reached. The rugged valleys, the craggy cliffs, the steep sides and rocky summits of the mountains, often furnish the most valuable guides to a knowledge of geological structure. Forsaking the path of the ordinary traveller, and plunging into the wildest and most unfrequented districts of the region he is exploring, the geologist is called upon to take the hunter of the mountains for his guide, and to thread the forest, to follow the rocky channel of the stream, or to climb the towering peak in search of further lights to aid him to sure and valuable determinations.

Amid the wild exhibitions of dislocation, frequently met with

in the mountains of this region, many interesting and useful facts have been observed, while the most striking features of scenery necessarily associated with the geological phenomena displayed, have been noted as suitable subjects for graphical illustration at some future day, when together with accurate geological sections illustrative of all the interesting points of structure in our state, it is my earnest wish to be enabled to present, from the pencil of a practised artist, a series of drawings combining similar instructive characteristics with the more attractive charms, imparted by a faithful delineation of the beautiful and imposing scenery in which our state so remarkably abounds.

Without entering into a detailed account, of either the general or minute investigations completed or in progress in this region, I would call the attention of the board to some of the inquiries prosecuted, and some of the results determined, in each of the three districts in question.

In the northern and middle districts, the interesting fact has now been conclusively ascertained, that the extensive beds of sandstone composing the hills along the western flank of the Blue Ridge, and sometimes lying upon the declivity of the mountain, or resting in lofty peaks near its summit, are subjacent in geological position to the great limestone formation of the valley; and that from the peculiar attitude in which this rock is found, and the marine and littoral impressions with which it is sometimes crowded, it marks out the ancient coast-line of a wide spread sea, beneath whose waters the vast extent of sedimentary rocks stretching westward from the ridge, were successively deposited. This rock has in many places been found to contain beds of iron ore, though in general of inferior quality to that met with in the limestone of the valley.

The Massanutten ranges, including the Massanutten proper, the Middle, Three-Topped, Peaked and other mountains, as well as the subordinate hills, and the intervening valleys, have been the subject of careful study; and a clear knowledge has been attained of the structure and contents of nearly the whole region, from the Peak, near Keezle Town, to the northern termination of these mountains, opposite Strasburg. Amid the indica-

tions of extraordinary violence, marking the rugged scenery of this remarkable region, the most beautiful symmetry in the arrangement of the component strata of the hills and valleys has been found to prevail; leading to interesting practical conclusions as to the extent and continuity of the useful mineral productions which it contains.

The heavy beds of valuable iron ore, of which extensive exposures have already been brought to light in supplying this material to the neighbouring furnaces, have been traced for great distances along the borders of the slate, subjacent to the massive sandstone, of which the principal ridges are composed; and an ore of still superior quality, associated with the red and variegated shales, higher up in the geological series, has been discovered in many parts of the Big and Little Fort valleys, exposed in layers; which, from the extent of the line of their outcrop, are probably continuously associated with the strata, to which they appertain. Looking to the relation now proved to exist between the rocks of this region, and the limestone of the valley on either side, the hope that has from time to time been entertained of the discovery of coal within these mountains, is to be looked upon as entirely without grounds; beds of this material have in no instance been discovered in strata so low in our geological series as are the slates and sandstones of which this region is composed, nor have any indications of it ever been observed in these rocks either in Pennsylvania or this state. In thus prominently and decidedly announcing this negative result, it is scarcely necessary to remark, that however opposed may be such a conclusion to the wishes of those who fondly imagine that every variety of mineral treasure is to be found in every portion of our mountain districts, much good is likely to result from a determination calculated to prevent explorations which could only lead to disappointment, and perhaps terminate in serious loss.

The wide belt of slate forming the basis of the sandstones of the Massanutten ranges, and extending in the same general direction into Maryland on the one side, and into the southern parts of the valley on the other, has been traced throughout a con-

siderable portion of these districts, and its boundaries carefully noted down; at the same time that the iron and manganese ore, which it contains, have been attentively examined.

Observation has also been directed to the numerous varieties of limestone forming the great agricultural wealth of our valley counties, in these districts as well as farther south. Additional specimens have been collected with a view to the systematic arrangement of the several distinct species of this rock, under the heads of simply calcareous, or magnesian, or hydraulic, according to the results of chemical examination. The iron ores associated with these strata, have also been examined at various points, and specimens reserved for similar practical objects.

In that portion of the two districts in question, extending from the western boundary of the valley limestone to the escarpment of the Alleghany rocks, research has been more especially directed to the region lying west of the Cacapon river, and of the Great Shenandoah mountain, although numerous sections have been made crossing the intervening belt. In the adoption of this course, I have been influenced by the results of former observations, leading to the conclusion that the low ranges flanking the valley to the west could never be satisfactorily investigated until the structure of the region beyond was clearly understood. From the very remarkable geological appearances generally presented, where the most eastern of these ranges meets the valley rocks, it became apparent during the last year, that the usual and otherwise invariable order of succession of the several members of our series of rocks was here violently interrupted, and that the limestone, one of the lower members of the group, was brought in contact with strata nearly approaching in position to the carboniferous slates and sandstones so widely extended over the region westward of the Alleghany. This line of fault, of which indications are to be met with at most of the gaps immediately west of the valley, appears to extend with but little interruption throughout the whole length of the state, and presents a striking illustration of the stupendous violence of the forces by whose agency the strata of the valley and of the parallel mountain chains lying to its west, have been caused to assume the posi-

tions which they now exhibit. Without entering more into detail in regard to this interesting and extraordinary feature in our geology, it will be apparent to the board, that repeated and careful observations made at various points along this line of dislocation, must be requisite to a sure determination of the point in the geological scale to which the strata thus abutting against the valley should be referred. And the more caution is required in this investigation as these strata have in many places been found to contain an anthracite or a semi-bituminous coal, and the probability of its continuity or available importance, might in some degree depend on the opinion formed of the rocks with which it is associated. While from these considerations, I directed examination chiefly to the region situated more to the west, so that in another season we might approach this tract of more perplexing difficulty with the useful lights afforded by a clear knowledge of strata whose connexion we could trace with them, attention has been incidentally bestowed at several points upon the coal-bearing rocks adjacent to the valley. The interest naturally felt in the existence of a deposit of coal appearing at many localities along the line in question, and from its vicinity to a populous and thriving region, invested with peculiar importance, renders me reluctant without much more detailed examination than I have yet bestowed upon it, to venture upon an opinion as to its actual extent, or to affirm positively its position in the geological series, as compared with the anthracite of Pennsylvania, or the bituminous coal of our western counties. This much, however, I may with propriety declare, that though undoubtedly far less extensive than the formation in Pennsylvania, its almost unquestionable continuity in some districts, as for instance, in Montgomery, Wythe, &c. over great distances, and the available thickness and good quality of the coal where exposed, lead to the opinion that it is destined at some day to become an important item in the resources of the surrounding region. I may venture further to add, though reserving this opinion to be corrected by future observations, that from the examinations thus far made, the rocks with which this coal is associated would appear to occupy a lower place in the series than the bituminous

coal measures of the west, or the shales and sandstones of the anthracite of Pennsylvania; and that they will probably, in most cases, be found to refer themselves to the most inferior member of the group. In what is here stated in relation to our anthracite and semi-bituminous coal, the board will understand me as not confining my remarks to the two districts of which I am at present treating, but as designing them to apply also to the southern district.

In pursuing our researches to the west, of the belt of which we have just been speaking, the general arrangement of the strata, which, with the assistance of Professor H. D. Rogers, I had been enabled to establish during the preceding season, as applicable to Virginia and Pennsylvania, and which he has since ascertained, with some modifications, to apply to New York, was found to furnish an invaluable guide. Directed by this arrangement, of which a descriptive account will hereafter be given, the explorations in Hampshire, a part of Morgan, Hardy, Pendleton, Bath, Pocahontas, Alleghany, and portions of Greenbrier and Monroe, were conducted with great minuteness of detail and with the most satisfactory results. Without entering into the particulars of our investigations, I would mention as illustrating the activity and success with which our researches were carried on, that a complete and accurate acquaintance with the structure of a large part of the region referred to has been attained, and with the materials now in hand, the space occupied by the several rocks throughout a wide area, could be delineated in geological colours on the state map. In these minute inquiries, as necessary data for obtaining valuable practical results, the various modifications of geological arrangement occurring at different points of each valley and range of mountains were carefully traced out.

Among the facts of economical interest developed in the course of these researches, may be mentioned the determination of the almost uniform occurrence of a peculiarly valuable description of iron ore in connexion with a certain member of our series of rocks, frequently displayed for great distances along the sides and summits of the ridges in this region. This ore

presents itself in layers arranged parallel with each other, and separated by thin strata of a reddish shale. Though rarely occurring in single beds of great thickness, the multiplication of small seams, exhibited at numerous points, indicate the abundance in which it might be procured, while the friable and yielding condition of the enclosing material would greatly facilitate its removal from the places in which it is imbedded. In the Knobly, New creek, Patterson's creek, Capon, North fork, Prop's gap, South branch, Warm spring, Bullpasture and Back creek mountains, and in fact in a great majority of the more considerable ridges of this region, the presence of this ore has been recognized either at isolated points, or continuously for a length of several miles, exhibiting in all cases the same associated shales, and occupying an invariable station in the geological series. Of the extraordinary value of this ore, the experience of the furnaces in Pennsylvania, where it has recently been brought into use, furnishes the most conclusive evidence. And since the discovery of its admirable adaptation for the furnace, it has been keenly sought after, and seams, which if of a different material, would from their thinness have remained unnoticed, have not only been diligently but profitably worked. In alluding to this important fact, the board will permit me to say, that it is not a little gratifying to me to have reached a result, thus illustrative of the advantages of the mode of research which has been pursued, and of the utility of that systematic delineation of the strata, which it is hoped, will form one of the crowning works of the survey.

Without attempting to particularize economical or general results, it may be proper to add that the limestones, frequently developed to a considerable extent in this region, giving fertility to many of the long and narrow valleys, and providing a rich natural pasturage on the broad and undulating tops of many of the mountains, has been the subject of attentive observation and analysis. It is a fact of interest, though as yet but little known or appreciated, that owing to the extent to which one of these calcareous rocks is frequently spread out upon the summits of some of the more massive of these ridges, soils of a highly productive character are often to be met with in positions where it

might be supposed they would be least likely to occur; and the traveller, who has bestowed no attention upon the geological structure of the mountains, cannot fail to experience the most gratifying surprise when, after toiling over hills of slate, and climbing a rocky defile over fragments, and amid impending cliffs of sterile sandstone, he finds himself suddenly on the margin of an undulating plateau of shales and limestones, in an open and in some cases a cultivated region. On the Knobly, the Prop's gap, Bullpasture and other ranges, these tracts, of high agricultural value, are continuously exposed. I may here add that the occurrence of this limestone in immediate contiguity with the red shale, of whose valuable contents I have already spoken, invest it with additional importance, and the existence in it of calcareous bands, capable of furnishing an excellent water cement, specimens of which are now in progress of analysis.

In the south-western portion of the region to which we are now alluding, commences an extensive tract of calcareous shales and sandstones, which, expanding in breadth as it stretches south and west, constitutes the rich agricultural and grazing regions of Pocahontas, Greenbrier, Monroe and Giles, and bestows productive soils upon the counties lying in the same direction, as far as the southern boundary of the state.

Of this important member of the series, Pennsylvania is almost entirely deprived, and the developement is comparatively inconsiderable, even in Virginia, until we reach the region just referred to, where its great expansion renders it a prominent and happy feature in the geology of the state. Although in the middle and southern districts, especially the former, the character of these shales and limestones have been carefully examined, and numerous specimens of the latter analyzed, much research yet remains to be bestowed upon them, both in connexion with their agricultural and economical value, and the origin of those medicinal ingredients which have given such merited celebrity to a number of our watering-places situated in the midst of these strata, and forming not one of the least of the blessings attendant upon the geological developement of this portion of our series of rocks.

The existence in this region of a highly valuable form of iron ore bearing some analogy to that last described, has been ascertained by observations at several points, and suggests the propriety and probable importance of further researches on the subject.

Of the progress and results of our researches in the southern district, some opinion will already have been formed from the general statements above submitted in relation to the other two subdivisions. It will be observed, however, that difficulties of a peculiar kind have attended our investigations in this district. The particular succession of limestones, slates and sandstones, forming the geological series to which the structure of the northern and middle districts has been in all cases satisfactorily referred, cannot be applied in elucidating the arrangement of the strata in the southern district, without considerable modification. Moreover, certain peculiarities of structure evidently related to the new direction of the Blue Ridge, and the parallel ranges north-west of the valley, while they increase the interest, augment the difficulty of the problems here offered for investigation. While, therefore, a large share of attention has been devoted to the examination of objects of economical importance, whenever they have been presented, much research has been necessary to remove the obscurity in which the geological order of the strata of this district was involved, and to arrive at sure conclusions as to the relations borne by them to the rocks of which the other districts were composed. In tracing the modifications of several of the members of the series, as they are prolonged in the south-west, and unfolding the nature and precise order of the strata as displayed in that portion of the state, considerable progress has been made, but further research is still required in regard to several important features in its geology. The board need not to be informed that it is by such researches, far more than by the mere examination of mineral localities, or the tracing of exposure of materials of economical value, that the useful objects of the survey are to be promoted. From the general uniformity with which particular ores or other useful minerals are associated with particular members of the series of rocks, as already illustrated in the case of the valuable iron ore

of Hampshire, Hardy, Pendleton, and other counties, it must be apparent that in tracing any individual rock throughout its course, and much more in developing the general order in which the strata are arranged, results of the highest utility are disclosed, illustrating equally the resources of all parts of the region investigated, and furnishing the only safe guide to the more minute examinations which are to form the basis of individual enterprise.

In pursuing these leading objects, a great number of transverse lines have been explored, extending in many instances entirely across the region, and including on the east a large portion of the rocks of the Blue Ridge, and the Pilot, Poplar Camp and Iron mountains, while numerous lines of observation connecting them have served to throw light on the structure of the intervening belts of country. As evidence of the extent and minuteness with which these preliminary examinations have been conducted, and as indicating some of the important general results to which they have led, I would refer the board to the approximate profiles, twenty in number, exhibiting the strata of this region, either throughout its entire breadth, or in particular portions, where more precise investigation was suggested by the peculiar importance or the difficulty of obtaining a clear knowledge of the geological structure involved. With these sections, amid the various determinations not embodied in them, as our guides, the operations of a future season will be greatly facilitated; and I feel assured that the obscurity yet remaining, in regard to the structure of some portions of this curious and affluent district of the State, will be satisfactorily removed.

At the same time that these more general and fundamental inquiries were in active progress, much attention was devoted to the examination of the known localities of iron ore, lead, gypsum, salt and coal, and to the further developement of these materials, by carefully tracing the strata with which they were found to be geologically associated. Of the important economical results to which these general as well as detailed explorations, when brought to a close, are likely to develope, it would of course be inexpedient as well as premature now to speak. I

may, however, be permitted to remark, that our investigations thus far have tended to confirm the favourable impression already existing as to the extent and variety of the mineral resources of this region. As conspicuous among the future sources of wealth and prosperity throughout this region, I may be again permitted to call the attention of the board to the extraordinary abundance and excellent qualities of its iron ores. Besides innumerable exposures of this material in various parts of the great limestone valley, and among the ridges lying to the north-west, I would particularly bring to notice the very extensive range of deposits which, commencing at Mack's run and pursuing a course parallel to the Poplar Camp and Iron mountains, within from two to four miles of their base, continues to the southern boundary of the state. In this region, from two to three miles in width, this ore is found in the flanks of the calcareous ridges in massive beds, frequently enclosed by walls of limestone, and usually of a quality admirably adapted to the uses of the furnace. There is, perhaps, no other portion of the great limestone valley, either in Pennsylvania or Virginia, so bountifully supplied with this material in so available a shape, and none in which this valuable resource has been more indolently improved. A deep sense of the almost unrivalled importance of the iron ores of this and the other districts referred to, must excuse the repeated allusions of which it has been the theme, especially when it is considered, that from the frequency of the occurrence of this material in various parts of the State, the high interest which ought to attach to such a possession does not appear to have been adequately felt.

In regard to the anthracite or semi-bituminous coal exposed at various points in the district here referred to, it would be premature in the present stage of our investigations, to present any further or more decided views than have been already submitted while alluding to the peculiar structure of the ranges on the western margin of the valley. I would, however, observe that much has already been done in ascertaining its geological position and economical character, both as presented under the circumstances alluded to in the Brush or Little Walker's mountain,

and under somewhat different relations in the Catawba mountain and the Peaked knob of Draper's mountain, as well as in some other localities in which small exposures have been discovered.

Of those peculiar and inestimable funds of mineral wealth, the salt, plaister and lead of this region, I feel justified in saying that the investigations bestowed on them during the past season, have served to impart even higher ideas of their importance than had already been formed, while I would add, that the inquiries relating to their extent are still in progress, and cannot be completed without much additional exploration.

In thus alluding to the economical bearings of our researches in this district in the course of the last season, I would call the attention of the board to a feature in its geology of great agricultural interest, and which, though locally well known, appears to be but imperfectly understood or appreciated by those residing at a distance: I allude to the large extent of surface occupied by calcareous rocks in that portion of the region lying to the north-west of the Gap or Walker's mountain. Without attempting to define the extensive valley and mountain tracts, thus prepared liberally to reward the toil and enterprise of the husbandman, it will be sufficient to remark, that from this cause large portions of Giles, Tazewell, Russell, Scott and Lee counties, presents a surface happily adapted to agricultural industry, combining the rich spontaneous growth of mountain pasturage, with the generous products of a lowland soil of unusual fertility. Nor can I, while alluding to these interesting features in the structure of the south-west portion of the state, avoid expressing the earnest hope, that in the progress of those great schemes of improvement which are daily giving fresh animation to the hopes of patriotism throughout Virginia, effectual measures will be adopted for giving access to these and other productive regions now lying uncultivated, neglected, and almost unknown. And looking to the influence which these facilities of communication will exert, may we not indulge the pleasing anticipation, that ere long the crowd of our emigrating fellow-citizens, now yearly thronging the great highways leading to the west and south,

will be invited to spread the blessings of agricultural enterprise and skill over the rich valleys and mountain sides of their native land.

It will be apparent, from the preceding remarks, that the determination of the order in which the several members of our geological series are arranged throughout the region west of the Blue Ridge, constitutes one of the most interesting and valuable results yet developed by the labours of the survey, not only leading to curious and important conclusions of a strictly scientific nature, but furnishing a sure guide to researches of economical value. In this aspect, therefore, and with the view of illustrating numerous allusions in the present report, as well as of affording useful practical suggestions to those who may be interested in developing the resources of the region in question, I feel assured that the board will not deem it uninteresting, in this place, to offer a brief description of the several important members of the series of rocks occupying the region west of the Blue Ridge, illustrating their economical character in connexion with their structure, position and extent.

Restricting our view to that portion of the region lying between the Blue Ridge and the coal-bearing rocks, forming the eastern escarpment of the Alleghany, which lies northward of the New River, we find that the whole of this vast territory is made up of sandstone, limestones, slates and shales, arranged in an invariable order of superposition, and capable of being readily arranged in a geological series, consisting of eleven distinct and well characterised members.

In regard to the continuation of this region through the southwest portion of the state, as formerly remarked, important modifications in some of the members of the series are found to occur, which although already to some extent traced out, have not been so completely developed as to warrant a full and determinate description of them at this time.

Throughout the whole of the vast area extending from the Blue Ridge westwards, the strata are for the most part of oceanic origin. In each of the eleven members of the series, as well as in the coal-bearing rocks lying still further west, the remains of

marine animals are frequently to be met with, and, in many instances, their relics constitute a large portion of the substance of the rock; thus confirming the inferences derived from the nature and structure of the materials of the strata themselves, and clearly attesting the fact of their having been deposited along the shores and at the bottom of a wide-spread ocean.

As already remarked, the position and character of the sandstone, resting in many places upon the western declivity of the Blue Ridge, and forming broken ranges of hills along its base, most distinctly and beautifully mark out the coast line of the ancient sea, while the peculiar impressions hereafter to be described, as so abundantly exhibited upon and throughout this rock, afford a striking confirmation of its littoral origin, or at least of its having been deposited in shallow water, and near the margin of the sea.

The view thus presented of the oceanic formation of the strata of this portion of the state, and the facts above referred to illustrating the eastern boundary of this ancient sea, though fraught with deep interest when considered merely in relation to the geology of our own territory, assume a far higher importance when associated with the more ample investigations and developements of Professor H. D. Rogers in Pennsylvania and New York. Studying the various members of the geological series, as they appear throughout large portions of those states and Virginia, identifying them as they are exhibited in the region of our great lakes, and in parts of the valley of the Mississippi, he has traced out the ancient coast line of the vast ocean, beneath which they were successively deposited, following its great inflexion as it bends westward along its northern margin—and thus connecting in one comprehensive and sublime generalization, the entire geological system of a large portion of our continent, and clearly demonstrating the operation of similar geological causes over an extent of territory, with a regularity of law of which there is perhaps no equally remarkable example in the whole field of modern exploration.

Description of the several Members of the Geological Series belonging to the Region West of the Blue Ridge.

Designating each member or group of rocks, by the number expressing its position in the series, the lowest being indicated by No. 1, and describing them in the ascending order, according to the law of superposition by which they have been found to be invariably arranged, we will commence with

(No. 1.)—This rock, or group of rocks, which is frequently exhibited in extensive exposures along the western side and base of the Blue Ridge, more especially in the middle counties of the valley, is usually a compact, rather fine-grained, white or yellowish gray sandstone. Where resting on the declivity of the ridge, it presents a gentle inclination to the north-west—while the subjacent and more ancient strata of the ridge, in almost every instance, dip steeply to the south-east. In Page, Rockingham, Augusta and Rockbridge counties this rock forms the irregular and broken ranges of hills lying immediately at the foot of the main Blue Ridge, and sometimes attaining an altitude little inferior to that of the principal mountain. A level region, sometimes of considerable breadth, and strewed profusely with the fragments of this rock, in general intervenes between these rugged hills and the first exposures of the valley limestone; thus indicating at once the extent of the formation, and the violence of the forces to which it has been subjected. In many instances two, sometimes three, ranges of hills are interposed between the limestone and what may be considered as the termination of the rocks of the Blue Ridge, in which case the sandstone of those nearest the ridge exhibits peculiarities of composition and structure which distinguish it from the rock found in more remote positions. Talcose and micaceous matter make their appearance in it; its specific gravity is increased, and a jointed structure is developed to so great a degree that it becomes difficult to recognise its true plane of dip. Of the innumerable cross joints by which it is subdivided into somewhat rhombic forms, the most conspicuous are those running N. E. and S. W., and im-

parting to the rock, though nearly horizontal in its bedding, the appearance of a steep south-easterly dip. This micaceous and talcose variety is sometimes found in the same hill underlying the more purely siliceous rock.

The latter, in nearly all the exposures from the Balcony falls to Thornton's gap, as well as in various other places, exhibits vague, fucoidal and zoophytic impressions on the surfaces of bedding, together with innumerable markings at right angles to the stratification, penetrating in straight lines to great depths in the rock, and from their frequency and parallelism determining its cleavage in nearly vertical planes. These markings are of a flattened, cylindrical form, from $\frac{1}{8}$th to $\frac{1}{10}$th of an inch broad, giving the surface of the fractured rock a ribbed appearance, and resembling perforations made in sand which have been subsequently filled up, without destroying the distinctness of the original impression. Precisely similar markings are found in great abundance in the white compact sandstone occurring at a higher point in the series, associated with numerous unequivocal impressions of fucoides.

The extent to which these sandstones are developed is comparatively inconsiderable in the southern and northern counties of the valley, and their structure and composition are in many respects materially changed.

The jointed structure so thoroughly pervades them in these districts, as to render it extremely difficult to ascertain the dip; but in numerous instances, especially in Floyd, Montgomery, Wythe, &c. the bedding is nearly vertical, dipping in most instances in conformity to the rocks of the Blue Ridge, that is, to the south and east. In no portion of the region occupied by these rocks can their nature and relations be more satisfactorily studied than along the eastern margin of Augusta, Rockingham and Page counties. In many parts of this district, not only the bold ranges of hills skirting the western base of the Blue Ridge, but several of the lofty peaks and ranges lying upon the western slope of the main mountain, are composed of these materials. At Mount Torrey, and Turk's, and Semon's gap, as well as at

numerous intervening points, this arrangement is strikingly observed; and as already remarked, the sandstone thus resting upon the breast, and near the main ridge of the mountain, presents a gentle but uniform inclination to the north-west. At Calloway's rocks, and the Black rocks, lying north of Turk's gap, stupendous exposures are to be seen; the rock in the two former instances being remarkably hard and sonorous, of a slightly ferruginous hue, and cleft by smooth joints at right angles to the bedding, which is nearly horizontal, thus presenting the appearance of huge blocks of masonry piled in massive rectangular columns on the top and sides of the ridge, where the exposures occur. In the knob, which towers to our left, as we commence our descent towards the valley along the Turk's gap road, the impressions or markings above described are abundantly exhibited. This vast mass of outlying sandstone, presents a gentle western inclination, while the rocks upon which it rests are seen dipping steeply to the south-east. These minute details in regard to the character of the rocks in question, together with the references to particular exposures calculated to illustrate their structure and arrangement will, I trust, not be deemed unimportant in a geological point of view, when it is considered that they relate to the first member of that vast series of strata whose law of succession we have proposed to elucidate, and that they mark out the commencement of a train of geological operations, which in their progress have given origin to the rocky strata of a large portion of the territory of the United States.

At the junction of these sandstones with the limestone of the valley, deposits of iron ore are occasionally to be found, which, although sometimes of a good quality, is often blended with oxide of manganese.

(No. 2.)—The second member of our series, is the valley limestone with its associated slaty and siliceous bands. Without entering into specific descriptions of all the marked varieties of this rock, occurring at various points within the valley or elsewhere, it will be sufficient at this time to refer to some of its

more distinguishing features, economically as well as geologically considered. Varying in colour from the deepest blue, approaching black, to a light gray, and sometimes an almost pure white, presenting every modification of texture from the uniform and compact grain of a marble, susceptible of the highest polish, to the soft, slaty, or harsh arenaceous structure, and exhibiting a composition equally diversified, varying from the pure calcareous spar, to the silicious, the aluminous, and the magnesian limestone, it is obvious, that no one general description will be applicable to its numerous modifications. For a mineralogical and chemical account of those varities, principally interesting in an economical point of view, I would refer to the observations and chemical results embraced in my last year's report. Numerous analyses have been made both before and since that time, and investigations on the same subject are still in progress.

With the view of affording further detailed information in regard to the constitution of these rocks, so important in their application to agricultural and architectural purposes, the following additional analytic results may here be usefully subjoined:

1. Hydraulic limestone from Reynolds's quarry, Shepherdstown, called gray cement. This specimen is of a light gray colour, rather slaty fracture, moderately fine texture, and dull lustre. In the 100 grains it yielded

Carbonate of lime, - -	23.90 grs.
Carbonate of magnesia, - -	24.36
Silica, - - - -	42.90
Ox. iron and alumina, - -	2.10
Water and loss, - - -	6.74

The very large proportion of silica present in this specimen, is the most remarkable feature in the above results, and illustrates what was formerly stated in regard to the highly silicious nature, in general, of the hydraulic limestones of our state. The following specimen from the same vicinity, presents a far less proportion of this ingredient:

2. Hydraulic limestone, Reynolds's quarry, very fine texture, and nearly white colour.

Carbonate of lime,	-	-	67.50 grs.
Carbonate of magnesia,	-	-	8.36
Silica,	-	-	12.60
Ox. iron and alumina,	-	-	7.00
Water and loss,	-	-	4.54

3. Limestone—near Charlestown, on the road to Locke's tavern—coarse grain, very hard, of a light gray colour, apparently hydraulic. This is one of the numerous localities situated on a belt of this rock, running east of Charlestown.

Carbonate of lime,	-	-	38.66
Carbonate of magnesia,	-	-	9.50
Silica,	-	-	42.50
Ox. iron,	-	-	2.00
Alumina,	-	-	1.50
Water and loss,	-	-	5.84

4. Limestone—four miles from Harper's Ferry, on the road to Martinsburg—coarse grain, light gray colour, tinged with red. This specimen presents the carbonate of lime with but little admixture, and forms an admirably pure lime.

Carbonate of lime,	-	-	95.86
Carbonate of magnesia,	-	-	1.46
Silica,	-	-	1.83
Ox. iron, alumina, water and loss,		-	0.85

5. Limestone—from half mile west of New Market—close and fine grained, fracture semi-conchoidal, dark dun colour. makes excellent lime.

Carbonate of lime.	-	-	86.16
Silica,	-	-	4.50
Ox. iron and alumina,	-	-	0.84
Water and loss,	-	-	6.50

This is destitute of all traces of magnesia.

6. Limestone—from near Luray—rather fine texture, and dingy blue colour, proposed to be used as a flux for iron.

Carbonate of lime,	-	-	78.00
Carbonate of magnesia,	-	-	11.37
Silica,	-	-	5.50
Ox. iron and alumina,	-	-	0.77
Water and loss,	-	-	4.86

7. Limestone—two miles from Christiansburg, towards Blacksburg, Montgomery county—rather coarse grain, irregular fracture, tendency to lamination, light grayish blue.

Carbonate of lime,	-	-	52.50
Carbonate of magnesia,	-	-	34.34
Silica,	-	-	6.84
Ox. iron and alumina,	-	-	0.84
Water and loss,	-	-	3.48

It should be remarked, in relation to these results, that while in the 4th and 5th specimens we are presented with examples of limestone of a very pure character, and especially suited to agricultural uses, in the others we have additional instances of the highly magnesian and hydraulic varieties, to which reference was made in the former report, and which are here introduced with the view of confirming the statements then given in regard to the usual aspect of limestones of this description. Respecting the dark blue or nearly black variety of which the composition was at that time particularly adverted to as eminently favourable to the production of a good agricultural lime, it is deemed unnecessary to add new chemical illustrations at this time. On this head I would merely remark, that the results of our analyses have been found very uniform in regard to this variety, always indicating great richness in carbonate of lime.

Adjacent to the Blue Ridge, more especially in the south-west counties of the valley, the limestone presents the jointed structure in a very remarkable degree. In Botetourt, Montgomery, Floyd, Wythe, &c. the innumerable subdivisions of the rock, marked by a net-work of veins of calcareous spar, the harsh and glistening appearance of its surface when fractured, and the nearly

vertical direction of its dip, would seem to indicate the modifying influences to which, from its proximity to the Blue Ridge, in the great expansion of that mountain to the south and west, it was here peculiarly exposed. In this region too, more than in any other portion of the valley, the general tendency of the limestone to a south-eastern dip is to be remarked—in fact it rarely shows itself in any other attitude, and then only for a small distance. The thin layers of a more or less calcareous, dark blue or brown slate, often interposed between the beds of limestone in the northern and middle counties, become more frequent and have greater magnitude in the south-west. There, as may be well seen in parts of Floyd and Montgomery, these interpolated slates of a brown, red, greenish-yellow, or blue colour, occupy a large surface, forming numerous steep ridges with intervening valleys or chasms in the vicinity of the Pilot mountain, and occurring also, though less abundantly, towards the north-west margin of the valley.

This member of our series, thus extensively exposed in the great valley of the state, is also occasionally brought to light at points more or less remotely to the west. Thus the beautiful valley of Crab-bottom in Pendleton, and the Warm spring valley in Bath, owe their fertility and their gracefully undulating surface to the presence of this rock. In both these instances, as might be expected, an anticlinal arrangement of the strata, giving rise to a narrow valley of elevation, has caused the exposure of the limestone, while the slate and sandstone constitute the third and fourth, or two succeeding members of the series, dipping away from the valley on both sides, from the hills or mountains by which it is enclosed.

Organic remains, though not in general abundant in the valley limestone, may be discovered sparsely distributed in many of the beds of which it is composed, and are found in particular layers or bands in the greatest profusion. It would appear that they become more numerous as we approach the upper limit of the limestone, where it adjoins the third or next superior member of our series. In these positions the rock is frequently crowded with impressions and remains of Encrinites, Spirifers,

Productas, Terebratulas, Orthoceratites, &c. In some of the slaty bands, and in the cherty beds so largely interstratified with the limestone of the valley, Goniatites, Ammonites, and other remains, are by no means unfrequent, and when found are generally in a beautiful state of preservation.

The travertine, or deposit marls, of which mention has been made on former occasions, though not peculiar to the limestone of which we are now treating, is so much more abundant in the great valley of the state, as to merit some notice in this place. From the extent of its exposures in many places, from its great richness in carbonate of lime, and from the facility with which, without any previous preparation, it can be applied to the soil, it certainly presents strong claims to the attention of the agriculturist; but, as yet, examples of its application are exceedingly rare, and never of satisfactory extent. With the view of inviting an earnest attention to this resource, by showing in how great a degree it abounds in calcareous matter, I subjoin the following chemical results. From these it will be seen, that if any good is to be anticipated from the employment of calcareous manures in this region—and of such a result experience leaves no doubt—great benefits may be predicted from the employment of these marls.

1. Marl from Tumbling run, 4 miles from Strasburg,
   Carbonate of lime, 84.5 grs. in the 100.
2. " from Hite's mill, 3 miles north of Strasburg,
   Carbonate of lime, 87.5
3. " from Flowing Spring run mill, 2½ miles from Charlestown, Carbonate of lime, 85.2
4. " from Brook creek, between Strasburg and Woodstock,
   Carbonate of lime, 85.2
5. " from the Opequon, between Winchester and Strasburg,
   Carbonate of lime, 89.7
6. " from 6 miles north of Woodstock,
   Carbonate of lime, 76.3
7. " same locality,
   Carbonate of lime, 91.0

8. " from Major Stuart's, near Waynesborough,
Carbonate of lime, 81.8
9. " from White Plains, near Newmarket, substratum in field, Carbonate of lime, 85.22
10. " same locality,
Carbonate of lime, 79.54
11. " same locality,
Carbonate of lime, 76.13

Besides these deposits of travertine marl, found in the valleys and along the rivulets, in almost every part of the valley, there occurs in several localities in Floyd county, a rocky travertine of great compactness and purity, and of a crystalline texture, adapting it to building or ornamental uses. Unlike the former variety, this occurs high up on the sides of the limestone hills, forming a mantle over the calcareous rock, and evidently deposited from springs or from the natural inundation of water issuing from the calcareous strata, here greatly fissured, and bringing with it large quantities of the carbonate of lime in solution. In the same region, and associated with the valley limestone, occurs that interesting and valuable silicious deposit, the Montgomery Buhr. Varying from a grayish and yellowish white to a deep orange brown, and presenting a cellular texture and great hardness and sharpness of grit, this unique material possesses qualities which admirably adapt it to the formation of mill-stones; and is accordingly, though to a much less extent than could be wished, used for this purpose.

It is in this member of the series that the only available deposit of lead ore in the state occurs; a description of the several varieties of which, as found in Wythe, was given in the report of last year.

Another, and by far the most important, of the minerals it contains, is the iron ore, of which several of the most successful furnaces in the state have availed themselves, and of which, particularly as it occurs in the south-western counties, some description has already been given. This mineral presents the various forms of compact, earthy, cellular and pipe iron ore, and in general yields a metal of admirable quality.

(No. 3.)—This member of the series consists of slates and slaty sandstones, of various shades of bluish black, lead colour and yellowish brown, the dark varieties in general predominating. Their structure is laminated and fissile, not unfrequently evincing the presence of a small quantity of mica. When weathered they in most cases assume a yellowish or dingy brown appearance. Usually, this slate is devoid of carbonate of lime, though bands are occasionally met with, containing organic impressions, and of a composition more or less calcareous. Iron pyrites is of very common occurrence, giving origin to the sulphureous impregnation of numerous medicinal springs, taking their rise in these rocks, some of which, as the Shannondale and Winchester springs, have attained extensive reputation.

Resting immediately upon the upper boundary of the valley limestone, (No. 2,) this rock or group of strata is exhibited on a very extensive scale along the base and flanks of the Peaked mountain, and the Massanutten, and other parallel ranges, in Rockingham, Shenandoah, Page, &c. counties. From the synclinal structure of most of these ridges, the slate is exposed on both sides of the mountain, dipping inwards, that is, to the north-west on the eastern side, and to the south-east on the western side. The striking symmetry of contour exhibited by the Peaked mountain, when viewed endwise from a point south of the termination of the range, illustrates the basin-shaped arrangement of the strata of slate resting in a trough of the subjacent limestone, and surmounted by the sandstone which forms No. 4 of our series. There are few, perhaps no other exposures in the state in which the structure and relations of these slates can be so satisfactorily observed, as in the group of mountains here referred to; and in no part of this interesting region can such observations be made with more readiness, and more instructive results, than in the line from M'Gahey'sville, across the Peaked mountain, towards Keezle Town. Leaving the former place, which is situated in the valley limestone, we are accompanied for some distance by that rock, presenting a dip towards the mountain, that is, to the west and north. Quitting the limestone we enter upon the slate resting upon it and exhibiting the same

dip. This rock attends us as we ascend the eastern side of the ridge, always presenting the western dip, and exhibiting towards its upper boundary bands of a more calcareous nature, and thin layers of a dark brown slaty sandstone, both of which abound in impressions of encrini and other organic remains. This brings us to the massive white sandstone, hereafter to be described, which rests conformably on the slate, and forming a deep trough or narrow valley on the top of the range, is seen dipping towards the east and south, high up along the western side. Descending below this sandstone we reach the slate again, now dipping to the east and presenting the same characters as on the eastern slope. This continues to near the base, when we meet with the limestone dipping beneath the slate, or to the east, and thus completing the trough-shaped, or synclinal arrangement of the strata of the mountain. Beyond the northern termination of this group of mountains the slate forms a wide belt, passing through Frederick county and on to the Potomac, and imparting marked peculiarities to the topography and agricultural features of the region. A similar prolongation of this rock may be traced south of the Peak, near Keezle Town, extending with a variable breadth through Augusta county, where it is finely exposed on Christian's creek, near Staunton, and even passing into Rockbridge. Besides occurring in various other parts of the valley, in greater or less extent, it is also exhibited, as will readily be inferred, along the margins of those anticlinal valleys, such as Crab bottom and the Warm spring, in which No. 2 occurs, lying upon that rock, and presenting the same general characters as above described.

In an economical point of view, this rock is chiefly interesting, from being the repository of beds of iron ore of great extent and value, and of large deposits of the oxide of manganese. In regard to the former, incalculably the more important of the two, the extraordinary productiveness of this rock has already been illustrated in sketching some of the results of our researches in the Big and Little Fort valleys of the Massanutten. But I may be allowed again to call attention to the rich abundance and excellent quality of the iron ores appertaining to this

member of our series, as forming a part of the structure of those mountains, as well as to the ample deposits exhibited in numerous other localities in connexion with the same rock. Though not unfrequently impregnated with manganese, these ores are, for the most part, well adapted to the furnace, and yield a metal of excellent quality. Their position is generally near, or at the upper limits of the slate, or between it and the sandstone, and they seem to have been derived from the ferruginous ingredients of both these rocks, through the influence of slow chemical changes and infiltration.

From the resemblance this slate occasionally presents, both in colour and texture, to the shale of the coal measures, expensive explorations have been made with the view of reaching the coal it has been supposed to contain. But, as I have already stated, there is no warrant for such an opinion, either in the geological situation of the rock, or in the results of observation in Pennsylvania, as well as this state.

(No. 4.)—Resting upon the slates above described, there occurs a group of sandstones of which incidental mention has already been made in treating of those rocks, as exhibited in the Massanutten ranges. This member of our series may be described as consisting of alternations, generally two in number, of red or brown, and compact white sandstone, the former frequently graduating into an ochreous shale. The latter rests upon the shale or red sandstone in both instances, and from its massiveness, durability, and the whiteness of its weathered surfaces, forms a very conspicuous feature in the geological scenery of many of our mountains. Near the upper limits of this group, as well as in connexion with the shaly bands beneath, organic impressions are often abundantly discovered. The thin slabs of buff and olive sandstone lying near the top, are particularly rich in these remains, among which may be noted as peculiarly abundant, a small globose terebratula, and at least two well characterised species of fucoides. Cylindrical markings, similar to those of No. 1, are often exhibited in great numbers in the more compact and fine-grained white or pinkish white strata of this group. And iron ore is frequently associated with the more

slaty strata, and is of almost invariable occurrence in connexion with the ponderous brown sandstone which forms the boundary between this and the next superior member of the series.

In the Peaked, Massanutten, and other adjacent ridges, the shaly bands are scarcely to be discerned, while the white sandstones is developed in great extent, forming all the upper portion of the mountain, and presenting long lines of cliffs on either side. Here much of the rock is a coarse and very hard conglomerate, the fragments often angular, and generally but imperfectly water worn, thus adapting it to be used for millstones, and giving it a texture and aspect strikingly distinguishing it from the coarse sandstones and conglomerates occurring higher up in the series. In the region lying to the west or north-west of the great valley, where the chief exposures of this group of rocks occur, they present all the characters above described. In many of the more massive mountains in this part of the state, these strata are found in the interior of the range, forming one or more enormous and sometimes unbroken arches, sustaining the rocks placed higher in the series, and exhibiting in the natural sections by which the interior structure is exposed, some of the most wildly picturesque scenery in the state. The Great North mountain lying to the west of Rockingham and Shenandoah counties, is composed of this sandstone, even to its very summit; and on its top, and along its rugged and almost inaccessible sides, bears witness to the violence of the dislocating forces which have bent these massive strata into arches, broken them at sharp angles, and tilted them on end or folded them together.

Immediately exterior to the slate which rests anticlinally upon the limestone of the Warm springs, Crab bottom, and other valleys of elevation, these strata reposing upon the former, lie along the outer sides of the enclosing mountains, spreading a mantle of white and almost herbless rocks far down the declivity of the ridge, and forming a range of precipices, like a line of lofty battlements along the mountain top. Such are the curious and striking features presented in the Warm spring mountain, and the still more remarkable ridge, called the Devil's Backbone, as

well as in numerous other situations in which our researches have been pursued.

In numerous instances, of which the Knobly and North fork ranges may be taken as examples, the rocks of No. 4, rising in the middle of the mountain, in the form of a stupendous arch, divide the mountain into three parallel ridges; this rock composing the central one, and the rocks of 5, 6, &c. forming those on either side, thus presenting a beautiful symmetry of arrangement in the midst of apparent confusion, and indicating the extent to which denuding forces must have operated to remove the vast incumbent mass, which was borne up by the rising strata, when the great central arch was originally elevated.

Another very curious and striking exhibition of the rocks of No. 4, is displayed in the long line of hills, which is washed at its western base, by the waters of North fork of South branch of Potomac in Pendleton. Here the strata are literally on end, and the rocks of No. 4, instead of forming an arch, are folded together by a sudden bending at the top, as if the two sides of the arch, by the violence of lateral compression had been brought in contact, while the rocks of 5, 6, 7, &c. are symmetrically disposed in almost vertical planes on both sides of the crushed axis. The massive strata of No. 4, resisting the action of the weather, or of denuding forces, are seen towering above the adjacent more destructible rocks, and at each of the numerous openings in the range, these white sheets and grotesque pinnacles of rock, rising on either side, add a peculiar wildness to the vista-view of dark-wooded slopes of the Great North Fork mountain, of which we are thus permitted to obtain a glimpse.

The frequent connexion of this member of the series, with scenes of scientific or picturesque interest, might be illustrated by numerous other examples, but I will content myself with remarking, that in the Peter's, Wolf creek, and other mountains, in the south-west, this rock plays a conspicuous part; that in the Jack mountain, it presents two arches, one of them of enormous breadth, giving rise at their junction to the celebrated Barn rock; and in Brown's mountain, in Pocahontas county, it exhibits the curious spectacle of twelve arches, many of them entire and of

the most beautiful contour, occupying a distance of more than two miles along the bank of Nap's creek, where it traverses the mountain.

(No. 5.)—Next above the massive sandstones and shales just described, is a group of soft slates and shaly sandstones, with occasional calcareous bands, of various tints of brown, yellow, green and lead colour, frequently presenting a mottled aspect, especially from the occurrence of blotches of green and yellow, in the more massive dark brown strata. This member of the series, is of inconsiderable thickness in the middle district. It expands as it proceeds north, and in Hardy and Hampshire counties, where it is well developed, exerts a marked influence upon the topography of the mountains. From the readiness with which it is decomposed and worn down by the action of the atmosphere or other causes, it usually imparts to the tops or sides of the mountains in which it is exposed, an undulating form, and occasions that peculiarity of topography already adverted to, in describing the triple structure of parts of the Knobly mountain.

In the south-western counties this member of the series becomes far more largely developed, embracing in addition to the shaly strata, numerous beds of sandstone, and containing that peculiar species of slate which forms the repository of the vast beds of gypsum in the valley of the Holston. In fact, in that region the developement of these parti-coloured and calcareous shales is even greater than in the heart of Pennsylvania, and seems to bear a marked resemblance to the expanded form in which they occur in the gypsum and salt region of New York. The transition of these strata from the comparatively insignificant dimensions which they present in the middle district, to their expanded form in the south-west, has yet been but imperfectly traced, and will afford an interesting subject for future investigation, especially as connected with the precise determination of the boundaries of the gypseous and saliferous rocks.

As already indicated, these shales are the repository of the very valuable form of iron ore previously mentioned. From its occurrence in thin beds, interstratified with the calcareous shales, from its being usually filled with impressions or hollow casts of

shells and other organic remains, and from its resemblance to a dark brown fossiliferous slate or sandstone, it admits of being very readily identified, even by those but little accustomed to the examination of minerals. So uniform appears to be the association of this ore with the present member of our series, that besides being exposed in most of the ridges of Hampshire, Hardy, Bath, &c., as formerly stated, it is exhibited at many points in the valleys of the Massanutten, where these shales are brought to light. The observations already made upon the economical importance of this ore, will, it is hoped, invite attention to it, and the above descriptive remarks, in regard to its form and geological relations, may prove useful in aiding its developement.

(No. 6.)—Overlying the strata above described, and often blending with them by repeated alternations of shale and limestone in thin beds, we meet with a limestone of more massive character, though still at intervals presenting the shaly hue and structure. This member of the series is remarkable for its richness in Encrinites, shells and other organic remains. In fact, many of the strata, especially towards its upper limits, have the appearance of being entirely formed of these exuviæ. In the northern and middle districts, where its characters are most uniform, and have been most extensively observed, it is found to assume a more arenaceous structure as it approaches the overlying sandstone No. 7, and when seen in mass exhibits a peculiar rough and mealy surface, which makes it easy to be recognised. When bruised or rubbed, especially if the experiment be made with a fragment from the upper beds, it exhales a strong bituminous odour. In many of the exposures of this rock, the beds adjacent to the sandstone No. 7, are interspersed with small calcareous and silicious pebbles. The lower strata of No. 7, are separated from each other by thin layers of a highly bituminous conglomerate of the same description, of which in some places I have counted twenty in the space of thirty feet. In the southwest, the developement of this limestone appears to be co-extensive with that of the subjacent shales. Extending from the western base of Walker's mountain to the commencement of the gypseous shales, in the valley of the north fork of Holston, it

imparts fertility, together with a singularly picturesque character, to that interesting region. Though less abundant in organic remains here than farther north, it still contains them in some of its strata in great numbers. The cherty beds which occur as we approach the sandstone, are sometimes of very considerable thickness, in the northern and middle districts. In the southwest, a chert or buhr rock, of superior quality, is found at its lower limits, and adjacent to the shales. In this district a more shaly structure of the limestone presents itself in approaching the overlying sandstone, and near the foot of the western slope of Walker's mountain, a reddish shale occurs in heavy beds. In an economical point of view, this member of the series has strong claims to our interest, from the fact that it is the only limestone exposed over wide tracts of our mountainous regions, and is often extensively spread out along the tops or on the flanks of the broader ridges. In Hampshire, Hardy, Pendleton, Bath, Alleghany, &c. counties, numerous available quarries are to be found, furnishing a material well adapted to the manufacture of lime for agricultural or building purposes, and as will hereafter be pointed out, the slaty soils of No. 8, occurring in the contiguous hills and valleys, are of a nature to receive peculiar benefits from the application of this species of manure. As presenting extensive and interesting exposures of this limestone, I may refer to the Knobly, Patterson's creek, Capon, North fork, Prop's gap, Bullpasture and Back creek mountains, and to the valleys of North fork of South branch, Jackson's river, Cowpasture, Walker's creek, and North fork of Holston; in all of which regions, it furnishes a resource of no inconsiderable value.

(No. 7.)—The sandstones composing this member of the series, are in general, characterised by an open and rather coarse texture, and an extraordinary abundance of organic impressions. In colour they vary from a yellowish white to a dark greenish gray. They are usually presented, especially the lighter coloured variety in massive beds of several feet in thickness, and from their frequent occurrence along the flanks and declivities of the ridges, dipping at a steep angle, and bare of vegetation, they form a curious feature in many of the wild scenes among our

mountains. Frequently exposed in broad sheets of remarkable whiteness, high up upon the sides of the hills, they arrest the attention of the traveller, even when at a distance, and still more interest his curiosity, when upon a nearer inspection he finds them teeming with the relics of a former animated world, and exhibiting over wide surfaces of exposure, a display of these remains at once prodigal and diversified, and full of useful illustration to the geologist.

The arched structure remarked upon in describing the sandstone No. 4. is also conspicuously and beautifully displayed by this member of the series. Frequent exhibitions of continuous and successive arches of admirable symmetry and imposing grandeur, are met with in the northern and middle districts, where the deep gaps in many of the ridges admit us to a view of these sandstones, and occasionally the subjacent limestone. A noble specimen of scenery of this kind is to be found at what are called the Hanging rocks, in the neighbourhood of Romney, where the South branch mountain gives passage to the South branch of the Potomac, flowing towards the east. Here the river flows along the base of a long line of precipitous rocks, arranged in the form of three stupendous arches, of which the most eastern is 250, the second 550, and the third 220 yards in span. Nearly all the mountains of Hampshire, Hardy, Pendleton, Bath, Pocahontas and Alleghany counties, previously referred to, exhibit extensive and instructive exposures of this rock —which from its whiteness, frequently bare surface, profusion of organic impressions, and disposition to disintegrate into a coarse white sand, is one of the most strongly and uniformly characterised of the members of our series.

An iron ore has been found in various places in connexion with these strata, but of its extent and probable value, I am not yet prepared to speak.

(No. 8.)—Resting in contact with the sandstones above described, and usually forming the lower hilly slope of the mountains in which they occur in arched or anticlinal form, we meet with a dark-coloured and very fissile slate, which constitutes the lowest bed of the group of slaty rocks forming the eighth mem-

ber of the series. These strata which occupy a large extent of surface in our mountain region, are not less conspicuously characterised by the topographical features to which they give rise, than by their marked peculiarities of hue and structure. Sharp, irregular hills, deeply furrowed on their sides, and succeeding each other with but little order or arrangement, mark the topography of the regions in which these rocks occur. A further and equally conspicuous characteristic of the rocks in question, consists in their frequent and remarkable contortions, a phenomenon well calculated to awaken curiosity and surprise wherever they are extensively exposed. Very obvious differences of structure and external characters are presented in different portions of this series of slates, and have suggested the propriety of a triple subdivision of the strata. The lowest of these rocks, or that which rests upon the sandstone, No. 7, distinguished by its bluish black colour, and by its scaly and fissile texture, causing it to fall into thin wafer-like fragments, or to crumble in slender fibre-like pieces, resembling portions of decaying wood, I have designated as the black fissile slate of No. 8. The second variety, presenting various dark shades of green, but more especially remarkable for a deep olive tinge which is most pleasingly displayed in the weathered and fragmentary condition of the rock as it occurs along some of the highways of the state, I have denominated the olive slate of No. 8. The third, which is much less uniform in appearance, or homogeneous in composition, than either of the preceding, embraces many beds of more massive structure, exhibiting especially in its lower and middle portions, a yellowish green and a deep brown colouring, and always distinguished by the rusty or ochreous staining of its weathered surfaces. Becoming more silicious as we approach its upper boundary, it terminates in thick beds of sandstone of a dirty gray colour, frequently mottled with purple or greenish spots. This I have named the ochreous portion of No. 8.

The presence of iron pyrites in nodules, generally of a spheroidal form, or in a disseminated state, especially in the lowest of the subdivisions above described, favours the disintegration of the rock, gives rise to the incrustations of alum, copperas and

gypsum, with which its exposed surface is usually overspread, and imparts to the springs arising in it, that sulphureous and chalybeate impregnation for which they are generally remarked. Though not in general rich in organic remains, these slates contain many bands or thin beds abounding in them in a very high degree. Encrinites, Spirifers, Productas, Terebratulas, are crowded together in the closest contact, and furnish interesting specimens for geological comparison and description. These organic layers, are, or evidently have been, more or less calcareous. A stratum of limestone of pretty good quality, and two or three feet in thickness, is frequently found interpolated among the upper beds of these slates, and is remarkable for the number and beauty of the impressions it contains.

The exposures of this member of the series are so numerous and extensive, that it is almost unnecessary to refer to particular districts for exemplification. I may, however, be allowed to remark upon some of its more important localities, as illustrating its geological position and characters. The Cowpasture hills, of which an interesting section may be observed along the turnpike road leading through Jennings's gap, together with much of the comparatively level region, extending to near the base of the Warm spring mountain, present admirable exposures of all the subdivisions of these slates, and strikingly exemplify their tendency to contorted arrangement. Similar and equally instructive exposures are exhibited throughout a large part of the route from the Warm spring valley, by Cedar creek and Callahan's, to the White Sulphur springs. Occasionally the subjacent sandstone, No. 7, rises into view, and sometimes even the limestone, No. 6, still lower in the series, is brought up as at Callahan's rock; but for the most part, the road winds among the steep and broken hills of No. 8, occasionally exposing portions of the next superior member of the series. The ridges usually designated as the Alleghany in this portion of the state, forming the eastern boundary of Pocahontas county, and lying west and north of the Warm and Sweet spring valleys, are for the most part made up of the rocks of No. 8, capped in some places by the lower rocks of No. 9. In the structure of the Branch, or Great She-

nandoah mountain, the relations of these slates are well exposed. The basin-shaped or synclinal arrangement of the rocks of this lofty and rugged range, exhibits these strata dipping under the mountain, on both its eastern and western flanks, and forming the wildly broken, and strongly shaded hills, which are crowded along its sides.

The hills whose diversified and picturesque outlines, impart such interest to the scenery around the White Sulphur springs, are chiefly composed of these slates, the lowermost division of which may be seen in various points, resting on the flanks of the sandstone hill (No. 7,) from the bosom of which the waters of the spring make their escape. These rocks accompany us for some distance towards the Greenbrier river, and then give place successively, to the higher members of the series, until we find ourselves surrounded by the strata of No. 11, in the vicinity of that stream.

In Hampshire, Hardy and Pendleton counties, the strata No. 8, are extensively exposed along the sides of the anticlinal ridges, such as the Capon, Sandy, Patterson's creek, South branch, Knobly, North fork and Bullpasture mountains, and occupy most of the intervening valleys. In Bath, Alleghany, parts of Greenbrier and Monroe, Rockbridge and Botetourt, as well as some of the more southern counties, their topographical relations are much the same; though in proceeding far south, important modifications arise, both in the material and structure of these slates.

Iron ore, and manganese are met with in these rocks. Thin beds of bituminous shale, with small laminæ of impure coal, have been discovered at several points in the lowermost strata, but thus far the results of our observations are such as to discountenance any probability of finding this mineral in available quantities in the rocks of No. 8.

It may not be unimportant to remark, that the soils produced by these slates are of very various degrees of productiveness; some being distinguished for their fertility, whilst others yield the farmer comparatively stinted returns. But in all cases, they appear to possess a peculiar susceptibility of improvement, from the application of lime, or calcareous matter in other forms. This in-

teresting fact, evinced by observations in several localities, is strikingly in harmony with the results of experiments in other quarters of the state, where soils or clay, imbued with the sulphates found in these slates (alum and copperas,) have been rendered quite productive by the addition of marl. As gypsum is not unfrequently found in the efflorescence on these slaty rocks, and as moreover, I have detected it in the slaty fragments mixed with the soil in several places, we naturally look to it as one of the causes of the superior fertility which some of these soils exhibit, while we would explain the amelioration of others when acted upon by lime, by the readiness with which, under these circumstances, gypsum would be formed. It is interesting further to remark, that the means of improving these slaty soils is generally within easy reach—as from the usually steep inclination of the strata, we have to proceed but a small distance before we reach the outcrop of limestone beds of No. 6. Indeed in a great majority of cases, these strata are exposed in the gaps, and along the flanks of the hills enclosing the region in which the soils demanding the application of lime occur.

Sulphuretted waters are of very common occurrence in No. 8. In general, the impregnation, gaseous as well as solid, is not great; but in many instances, it is fully competent to the production of striking remedial effects, and justifies the repute in which several of these waters are held.

(No. 9.)—This member of the series exhibits less constancy of character than the preceding. In the northern district, it consists of shales and slaty sandstones, generally of an argillaceous composition, and presenting an alternation of beds of brown, red, green, yellow and dark gray colouring. Proceeding south, the argillaceous composition and the variegated hues of these strata become less striking, until in the middle district a dark brown micaceous, and somewhat argillaceous sandstone, and slate, is found to occupy the principal share of this division of the series.

In Hampshire, where the rocks of No. 9, are beautifully exhibited in their variegated character, we would refer for localities to Townhill, and Big and Little Timber ridges. The synclinal

structure of the Shenandoah, or Branch mountain, of which mention has already been made, beautifully exposes these variegated shales along the higher portions of both the eastern and western slopes, first appearing immediately above the grayish sandstone of No 8, and terminating in the most elevated parts of the range at a small distance below the summit, which here is formed of the strata of the next superior member of the series. Farther south, along the same ridge, as at Dry river gap, and towards Shaw's ridge, the monotonous brown or dark reddish slate becomes predominant; and under the same modifications, these shales appear on the eastern declivity of the front ridge of the Alleghany near its base. In the neighbourhood of the White Sulphur, as before stated, between Huntersville and the Greenbrier river, in Pocahontas county, and in numerous other districts, these reddish slates of No. 9, are extensively exposed, but perhaps in no district do they present more satisfactory or striking developements, than in the wild gorges which lead from the limestone region of Rockingham, through a succession of precipitous and lofty hills, to the eastern base of the Shenandoah mountain. The strata dipping very gently to the east, in consequence of an anticlinal turn near the eastern foot of the ridge, we have here spread over an extensive surface, the rocks which with a steeper dip are compressed within a part of the altitude of the mountain, and the violence of denuding action have deeply channelled these nearly horizontal rocks, we are admitted to a view of a series of lofty precipices composed of the massive beds of No. 9, revealing most advantageously the composition and structure of the strata.

(No. 10.)—This consists of rocks of very heterogeneous character, though arranged in general with remarkable uniformity. A red sandstone containing white silicious pebbles, usually about a half inch in diameter—a gray, rather open-grained sandstone, and a beautiful white conglomerate—a coarse conglomerate, consisting of very large pebbles, embedded in a light olive or dingy green paste—yellowish, olive and dull red micaceous soft sandstones—having something of a shaly structure, constitute the principal rocks forming this curious group. Beautiful ripple

markings are often met with on the surfaces of the large slabs of the finer of these sandstones. Many of the strata of this, as well as the preceding member of the series, are remarkable for the facility with which they may be divided into thin slabs of uniform thickness, and great extent, and in virtue of this property, as well as the durable character of the rock, present an admirable material for building. The finer and harder variety, of a gray or light yellowish green colour, is often used for grindstones, for which it would appear to be admirably suited. When thus cleft, the surfaces of the slabs occasionally reveal superb collections of organic markings, among which fucoides and calamites deserve to be particularly mentioned. Laminæ of coal less than a quarter of an inch in thickness, have been remarked at several points in the more shaly strata of this group, but there is no reason to look for an important vein of this mineral among them. These rocks may be well seen near the bridge over Howard's creek, on the road from the White Sulphur to the Greenbrier river, and again a little east of that river, on the road from Huntersville to the base of the Greenbrier mountain. In the latter locality the coarse conglomerates are very extensively exhibited.

(No. 11.)—The group of limestones, shales and sandstones, composing this member of our series, possesses peculiar interest, as well on account of its geological and economical importance, as the extensive region over which it is spread, and to which it imparts fertility. As formerly remarked, near the northern boundary of the state the calcareous rocks, forming a portion of the group, are but slightly developed, and at some distance further north, in Pennsylvania, limestone, in the form of distinct beds, is entirely absent, although calcareous matter is found intermixed with the other materials of the shales. As we advance south the limestone assumes more and more importance, until upon reaching the borders of Greenbrier river in Pocahontas county, it rapidly spreads out on either hand, and widely mantles the couties of Greenbrier and Monroe, extending also over portions of Fayette, Giles, and the counties still more south. This great and sudden augmentation of topographical extent, is not, however, to be regarded as marking a corresponding degree of

expansion in the thickness of this member of the group. On the summit of the Alleghany, beyond the head of Seneca creek, as we enter Randolph county from the east, this rock, accompanied with variegated shales, is developed over a considerable surface, but its comparatively steep dip here, and for some distance further south, contracts the area of its exposure, while in Pocahontas, and still further to the south, it assumes a nearly horizontal attitude, gently undulating, but for the most part dipping to the west. Much of this limestone is distinguished by its argillaceous composition, presenting, when weathered, an ochreous yellow surface, arising from the removal of the carbonate of lime, which leaves the earthy matters, retaining the original form of the mass, but peculiarly liable to disintegrate by exposure, and giving rise to a light-coloured and tenacious clay. The purer varieties, of which also there are abundant exposures, are usually of a deep blue colour, and are found to produce a very strong lime. They are often highly bituminous, and in many cases contain a marked proportion of carbonate of magnesia. Numerous specimens are now in progress of analysis, of which, therefore, no special details can be presented at this time. It will suffice to remark, that they present similar variety, as to composition, and applicability to useful purposes, as the limestones of No. 2. Many of these strata are exceedingly rich in organic remains, of which a considerable number do not make their appearance in the lower members of our series. The variety, peculiar characters, and admirable preservation of these relics, will claim for them an attentive examination.

The shales already alluded to, as associated with the limestone of No 11, are remarkable for the richness of their purple, green and yellow tints, and in this particular, as well as in their peculiarly crumbly texture, when exposed, bearing a striking resemblance to the shales of No. 9, as exhibited in Hampshire and Hardy counties. The hues are, however, much more brilliant, and the more massive exposures in which they are seen give them a higher interest. While on the one hand graduating into strata of limestone, from the increasing predominance of calcareous matter, they are seen on the other, becoming more and more

arenaceous, until at length their usual character is merged in that of a yellowish or dark brown sandstone, generally of slaty structure, but presenting in some of its beds the hard and massive character of the sandstones lower down in the series. Of the full extent of these alternations in the members of the group forming No. 11, I am not yet prepared to speak with certainty, as the western confines of these rocks have as yet been inadequately explored.

It is, however, important to remark, that the seams of bituminous coal discovered in the vicinity of Lewisburg, as well as west of the Greenbrier river higher up, occurring in the sandstones of this group, and therefore below the true coal measures which appertain to the next member of our series, cannot be regarded as likely to prove of much value, the sandstones and shales in which they are found being themselves but a small subordinate formation, and the coal embedded among them in considerable quantity.

As among the valuable materials associated with the limestones and shales, just spoken of, I may be allowed again to notice an iron ore of highly promising character, which has been discovered at several points in Greenbrier and Monroe. Should I be correct in my opinion of its good qualities, and of this chemical examination will furnish the means of judging, its value will soon be duly appreciated, as it indicates a character greatly resembling that of the stratified ore of the shales of our No. 5, and I have reason to believe, may be obtained in abundant quantities.

The pleasing scenery of the region of these limestones and shales, so often adorned by a rich cultivation, strikingly exhibits the influence of geological structure on the resources and the prosperity of a country, by bringing into the strongest contrast the undulating region to which industry was invited, and which it is now rapidly beautifying, simply on account of the presence of calcareous rocks, and the rugged hills and mountains from which enterprise has been repelled by the presence of the barren sandstone, or the equally unproductive silicious and ferruginous slate. The calcareous nature of the variegated shales adapt them to the production of a genial soil, and thus we find a rich vegetation following the exposures of these rocks high up along

the slopes of many of the hills, until suddenly arrested by the barrier of sterile rocks above.

(No. 12.)—This member of our series, not falling within the region of our explorations during the past season, cannot be described at this time. Lying immediately beneath and incorporated with the widely extending coal measures of the west, its great importance will claim future detailed and extensive observations.

The above description of the several members or subdivisions of our series of rocks, in the order of their superposition, will, it is hoped, be found to contribute to useful as well as interesting results. While it will serve to elucidate many portions of the preceding reports, and form the key to much of the present, and those which are to follow, I would gladly believe that it will awaken a spirit of observation in regions where such a spirit may be beneficially exercised, giving to it a direction at once safe and conducive to success. Suggesting interesting practical inquiries, and guiding the researches of those who are in pursuit of economical results, it will give to the investigation of our geology, even in its scientific generalities, that stamp of practical usefulness which even those who, unaware of the relations of scientific truth to the welfare of society, will be constrained to recognize and admit.

APPENDIX.

From the statements which have now been presented in relation to the scene and objects, as well as a few of the results of our labours during the past season, some idea may be formed of the extent to which we were enabled to prosecute active operations in the field, and of the success that attended our researches. In further illustration of these points, and as intimately connected with the present and future usefulness, as well as with the progress of our investigations, I may be permitted briefly to advert to the following additional facts and considerations.

In pursuing the chemical inquiries connected with the survey, which have been for the most part conducted under my immediate superintendence at the University, the want of a laboratory more extensive and complete than that previously used, specially fitted up and provided for the work, has induced me to erect a building for the purpose at my own expense, furnished with ample means for analytical research. During a part of the autumn and up to this time, chemical inquiries have been in active progress in this establishment, and from the increased facilities thus afforded for the prosecution of this branch of our investigations, I indulge the hope of rendering it even more important and extensive than it has heretofore been. The high value of these researches, manifested by the eagerness with which the chemical details embodied in the annual reports are referred to for practical objects, is still more strikingly illustrated by the numerous inquiries addressed to me, and the numerous specimens transmitted for examination from various quarters of the state. The amount of chemical investigation thus bestowed upon the

materials of economical value, collected in our explorations or forwarded to us from localities not visited, though not mentioned in the annual reports, forms a very important item in the yearly operations of the laboratory, furnishing useful facts and valuable practical suggestions in relation to the nature and appropriate application of our marls, limestones, iron ores and other important mineral resources, and thus silently, but largely and continually, diffusing information of immediate practical utility to persons in every district of the State.

In the graphical department of the survey, considerable progress has been made in the construction of coloured sections, exhibiting the structure of the regions in which our inquiries have been pursued; but much additional work of this description is yet required to give the necessary fulness to our elucidation of the mountainous districts, and to this end numerous accurate measurements, and a large amount of other labour demanding topographical skill remain to be performed.

The number and the magnitude of the errors of our state map already incidentally mentioned, have been found to be so important as to render it extremely difficult and almost useless to introduce geological delineations upon its surface until the requisite corrections have been made. This we have endeavoured to do whenever in our power, and our corrections have already been neither few nor unimportant—but in view of the magnitude and high utility of this branch of our labours in regard to the geographical as well as geological uses of the map, I feel it to be my duty to add, that it would be desirable at as early a period as practicable to obtain additional force for topographical as well as geological operations. The board will better appreciate the grossness and the frequency of the blunders committed on the map from the following facts. On examining the county maps, in the archives of the State, from which the general map has been formed, the most extraordinary instances of inaccuracy or carelessness occur. The common boundary lines of two adjacent counties, which should be identical as to direction and length, are rarely found to correspond in the latter particular, often differing by a large amount. The adjoining parts of the

same river or stream are frequently incapable of being brought into juxtaposition without greatly distorting other portions of the map. In a multitude of cases the directions of streams and mountains, are falsely represented; sometimes objects of this kind are laid down where they have no existence, and still oftener omitted where they are sufficiently important to merit notice. The distances between places even of prominent note are greatly exaggerated or reduced, and in one instance observed during the last year the error was no less than the difference between four and twelve miles. Though pervading all parts of the map, to sôme extent, and not less manifest in some of the tide water counties than in the mountain districts, where the difficulties of measurement render them far more excusable, these errors are felt with particular inconvenience, in the geological delineation of the latter portion of the State, from the number of distinct rocks or groups of strata to be represented, from their being frequently crowded together in a narrow compass, and from their peculiar exposures being for the most part intimately connected with the topography of the mountains or valleys in which they appear. In attempting to represent them in geological colours upon the map, in many cases it was found that a great distortion of their relative position and extent would be rendered necessary in order to maintain a proper correspondence of the geological and topographical features of the district as they had been observed, so that in fact a large share of the great and permanent benefits anticipated from an accurate geological colouring of our map must obviously be sacrificed, unless efficient means be placed in our hands for correcting the numerous and glaring errors which so greatly impair its value in its present form. While, therefore, our attention will be directed to these corrections whenever within our power, I cannot but hope that in consideration of the great and various advantages of an improved State map, an adequate provision for this object will at some early day be placed at my disposal, thus enabling me to incorporate with a more faithful representation of the topography, a minute and accurate delineation of all the geological features of the State.

REPORT

OF THE PROGRESS OF

THE GEOLOGICAL SURVEY

OF THE

STATE OF VIRGINIA

FOR THE

YEAR 1839.

BY WILLIAM B. ROGERS,

Professor of Natural Philosophy in the University of Virginia.

RICHMOND:

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1840.

OFFICE OF THE BOARD OF PUBLIC WORKS,
5th February 1840.

SIR,

I herewith transmit the annual report of the geologist of the state for the past year, which you will please lay before the house of delegates.

This report relates to districts of the state not previously treated of, excepting incidentally in former reports, viz: the marl region south of James river—a portion of the southern district east of the Blue Ridge, &c.—and part of the great western coal region.

I am, very respectfully,

Your obedient servant,

DAVID CAMPBELL,
President of the Board of Public Works.

The honourable the Speaker of the House of Delegates.

REPORT.

In compliance with the law requiring the principal geologist annually to render an account of the progress of the geological survey, I beg leave to make the following report:

SECTION I.

The field operations of the survey were entered upon as usual early in the spring, and were continued without interruption from that time until late in the autumn. The weather throughout the season was in general favourable to our researches—and in some portions of the state scarcely a day occurred sufficiently inclement to compel a suspension of active operations.

The vacancy in the geological corps created by the resignation of Dr. W. E. A. Aikin, was filled as the board is aware by the appointment of professor C. Briggs, a gentleman already favourably known as one of the geologists recently engaged in the survey of the state of Ohio. This gentleman entered upon his duties as a member of our corps in the beginning of June.

Keeping in view the importance of continuing the several assistants in the districts with whose geological features they were already in some measure acquainted, the various fields of research appointed for the season's operations were allotted among them as follows:

To Dr. G. W. Boyd was entrusted the continuation of the minute researches in which he had been engaged during a part of the preceding year, in all that portion of the state embraced between the Blue Ridge and the head of tide which lies south of the range of Albemarle, Louisa and Goochland counties, comprehending in his duties the accurate tracing of the various narrow belts of limestone occurring in a portion of this region, as well as the determination of the limits of the interesting formation of shales and sand stones, prolonged in an irregular manner nearly through its whole extent, and linking his observations from point to point by numerous local and some extended sections, exhibiting the various rocks in the order in which they occur.

Mr. C. B. Hayden was employed during the early part of the season in exploring that division of the Tertiary marl region lying south of James river—in which only partial researches had hitherto been made—embracing portions of Norfolk, Isle of Wight, Nansemond, Surry and Greenesville, together with the whole of Southampton and Sussex counties. Having completed the allotted investigation in this district, he was directed to continue the examination of a portion of the Appalachian belt in Pendleton county, and thence to proceed to a

systematic examination of that division of the western coal region lying between the front ridge of the Alleghany and the Laurel hill, embracing Preston county, together with portions of Hampshire, Hardy, Randolph and Harrison counties.

In continuation of the enquiries commenced towards the close of the preceding season, professor James B. Rogers, after completing some measurements of importance in the Mill mountain and neighbouring ridges towards the east, and carrying an accurate section through the lower extremity of the Falling spring valley, was chiefly occupied in the investigation of the upper members of the Appalachian series of formations as developed on a scale of extraordinary magnitude along the eastern flanks of the Greenbrier, Sewell and Flat top mountains in Pocahontas, Greenbrier, Monroe, Fayette and Mercer counties, and in exploring the structure and contents of the widely expanded strata of coal bearing rocks incumbent on the former, as presented in the Sewell and other ridges to the west, and along the valleys of the great Kanawha and some of the tributary streams.

To Mr. J. Slade was allotted the task of reviewing that portion of the Appalachian belt, designated in former reports as the southern district, with the design of constructing a number of additional sections, rendered important by the peculiar intricacy of its geology, and of tracing with greater minuteness than had yet been done, those numerous remarkable dislocations, whose frequent and sudden changes of character are intimately connected with the development of materials of economical value, in their immediate neighbourhood, and are often essential to a knowledge of the structure as presented at points comparatively remote.

To Mr. Briggs was assigned the exploration of that portion of the coal region constituting the northwest district of the state, directing his attention for the present chiefly to the division of the coal bearing rocks hereafter to be described as the upper coal series, tracing the various coal seams and their accompanying strata as they successively present themselves on the Ohio and at other places in this part of the state—thence following them around as they curve across the southwest angle of Pennsylvania into Monongalia and Harrison counties, and marking the interesting mutations they undergo in penetrating more towards the east and south.

Of the diligence and ability with which the several members of the corps have prosecuted the numerous and often difficult investigations thus assigned them, it gives me pleasure to be enabled to speak in terms of unqualified commendation.

Since the close of our operations in the field, our attention has been devoted as usual to the arrangement of the various details collected during the season, and to the graphical and chemical departments of the survey. These labours will furnish employment for myself and several of my assistants until the opening of the next season, and will be continued as customary by myself until the period arrives for taking the field.

It gives me pleasure to state that in reviewing the labours of the past season, and comparing them with the amount of work yet required for the completion of our researches, I am confirmed in the opinion, announced in my last year's report, that with the present organization of the corps, an additional season for detailed investigation, and a succeeding year devoted to a revision of some portions of the field, and to the tasks of preparing the sections and maps, as well as the final report for publication, will enable me to bring the arduous labours of the survey to a satisfactory termination.

It is unnecessary to assure the board that I am truly anxious to complete the responsible task I have undertaken by the earliest practicable time consistent with the accuracy, and therefore the permanent importance, of all the economical and scientific results. That it has not been suffered to linger in my hands, must be abundantly evident upon comparing the progress thus far made in our survey with that of similar enterprises in some of the neighbouring states. Indeed, bearing in mind the superior extent of our territory and its unequalled variety, and perhaps complication of geological features, such a comparison will hardly fail to inspire a gratifying surprise that with means so much less ample we have been enabled to carry forward our enterprise with the rapidity and accuracy with which it has thus far progressed.

In expressing my solicitude for the early, but at the same time thorough completion of the work, I may be permitted to say, that besides the wish of rendering our results available to the public as promptly as possible, I am not uninfluenced by a desire to vindicate on grounds of utility the wise economy which first originated the survey, by presenting to my fellow-citizens what cannot be given in the annual reports, a detailed account of all its economical and scientific results, in a connected shape, and illustrated by an extensive cabinet of specimens, by numerous sections, and by a map of the state corrected in its topography, and geologically coloured. Nor will it be deemed unworthy the sympathies of the board or of the public to mention as an additional motive to expedition, the interest with which our labours in developing the diversified and often wonderful geological features of the state, are watched by the lovers of useful science in our own country and abroad—an interest, which kindly and cheeringly expressed, has not been without its effect in lightening the toil and sweetening the pleasure of investigation. Were it necessary to adduce further evidence of the anxious zeal with which I have unremittingly laboured to forward the operations of the survey, I might refer to the heavy expenses from year to year personally incurred in its behalf, without which it would have been scarcely possible to have brought our work to so advanced a stage as that to which it has now attained.

In selecting the districts upon which to dwell more particularly in the present report, I have conceived it to be most proper as well as most agreeable to the board and to the public to make choice of certain important divisions of the state hitherto but slightly noticed in my reports, but in which our researches for some time in progress

have at length been advanced nearly to their completion, and to occupy less time in the consideration of those of which general sketches accompanied with some prominent chemical and other local details have already been given to the public.

Influenced by these views I propose omitting for the present further particulars relating to the Appalachian region, of which some of the leading features have been described in my two preceding reports, and presenting a sketch somewhat in detail of the following districts.

1. That portion of the marl region situated between the James river and the Carolina line.
2. So much of the southern portion of the state lying east of the Blue Ridge and west of the marl region as has been explored in sufficient detail to enable me to report.
3. The coal basins lying in the northern corner of the state between the front ridge of the Alleghany and Laurel Hill.

In addition to the systematic sketches designed to be given of these several regions, I propose to annex a brief outline of our explorations in the valley of the Kanawha, and the lofty mountainous tract lying between the falls of that river and the western boundary of formation XI. in Greenbrier and the adjoining counties, as well as of some of our observations in the northwestern coal region, including the tongue of land lying along the Ohio river, and between the states of Ohio and Pennsylvania.

It is scarcely necessary to say, that though thus silent for the present in regard to the Appalachian region, excepting so far as a portion of it may be incidentally mentioned in treating of the higher formations adjoining it on the west, our revisionary labours in that part of the field have been actively pursued, and with many interesting results. As regards our further operations of a like nature in this important division of the state, I would add that the minute measurements which have been begun, for determining the varying thickness of the several formations, an object not unimportant in its economical bearings, will be continued as far as our means allow, into other portions of the region. Our numerous sections will at the same time be knit together and rendered more minutely accurate; the topography of the country will be more precisely determined, by the accumulation of data derived from the measurement of the heights of our principal mountains at various points, towards which a good deal has already been done—and further disclosures will be made of the iron ores or other useful minerals described in preceding reports, as being associated with the several groups of strata forming the Appalachian zone. The familiar knowledge we now possess of the structure of every portion of this region, facilitates the progress of these measurements by guiding to suitable lines or points of examination. While connecting this accurate knowledge of the structure and arrangement of the rocks, with the precise determination of their thicknesses and the heights of the ridges in our numerous sections, we are enabled to give that finish to the work already performed, which will make our final representations in a graphical shape creditable to the state and worthy the accurate spirit of modern geological research, as exemplified in the works of European geologists.

In regard to the chemical investigations relating to the materials of this region, it is proper to say that a part of the labours of the laboratory will still be directed to the examination of the ores, limestones or other interesting substances embraced in the Appalachian formations, and as will be seen in the sequel, a number of such results will be included in the chemical division of the present report.

SECTION II.

TERTIARY MARL REGION SOUTH OF THE JAMES RIVER.

CHAP. 1.

Sketch of the Boundaries, Topography and General Geology of the Region.

During the operations of a preceding season, a careful examination was made of both sides of the James river, from its mouth as high up as the commencement of the primary rocks at Richmond, as well as of all its tributaries for some distance inland; and in my report for that year a brief account was given of the general results of those detailed enquiries, accompanied by a table of the composition of one hundred and sixty specimens of marl, of which sixty were from localities in the region south of the river. These enquiries having embraced the shores of the Elizabeth and Nansemond rivers, and Pagan creek, as well as of the Appomattox as high as Petersburg, our researches during the past season were directed to a minute exploration of the Blackwater, Nottoway and Meherrin rivers and all their branches, and an examination of localities remote from these streams, in which beds of marl were known or believed to exist. In prosecuting these labours, only a few interesting exposures have been left unvisited, chiefly in the inland parts of Prince George and Surry counties, and these will claim an early attention in the operations of the next season. Of the numerous specimens collected in the course of the season's operations, nearly all have since been submitted to chemical examination, the results of which will be given at the conclusion of this division of my report. Without entering into minute detail in regard to the numerous extensive exposures of the Tertiary marl occurring throughout this region, I propose at present to give a brief account of its boundaries, and of the order of superposition in which its well marked subdivisions have been found to be arranged.

The region bounded by the James river on the north, the Atlantic on the east, the state line on the south, and the irregular margin of the primary rocks on the west, may be regarded as consisting of two plateaus or wide benches of land, of which that lying towards the west preserves a general level much higher and less uniformly horizontal than the other. The latter extending from the sea shore to an inflected line lying a little east of the meridian of Suffolk, presents an unbroken plane, elevated from 8 to 12 feet above tide, rarely inter-

rupted by ravines, and penetrated only by tidal creeks enclosed by shores which for the most part slope gently down to the level of the water. The absence of running streams incident to this feature in the topography of the country is supplied by the moving power of wind, which by its periodical flow, especially in the vicinity of the James river and the Atlantic, gives motion to numerous wind mills here in use. The surface of this extensive flat, where not covered by swamps or morasses, consists of light coloured sands and clays, generally of a fine texture, and never enclosing pebbles of large dimensions. Beneath this the shell marl has been discovered only at a few points, and those situated near the eastern margin of the higher plateau.

From Sewall's Point to the bay shore, and along that shore, as well as the coast line of the Atlantic, a more irregular topography prevails, caused by the sandy knolls or dunes accumulated by the combined action of the winds and waves.

These at some places, as for example at Willoughby's Point, are more than thirty feet in height, containing scattered shells and fragments, such as are found in the contiguous waters, which have been conveyed from the beach by the same transporting agencies that have heaped up the mounds of enclosing sand. On some of these dunes a soil has been formed capable of nourishing large trees.

As might be expected, evidences are frequently met with of changes having occurred in the outline of the beach, the roots of trees being seen in many places in shallow water at a distance of several hundred yards beyond the present line of tide, and at other points equally distant inland, under circumstances shewing that they once grew upon the margin of the beach.

The higher plateau lying to the west of the extensive flat above described, extends from the line formerly indicated as a little east of the meridian of Suffolk, westwards to the commencement of the primary rocks, maintaining a general level of from thirty to fifty feet above tide, and slightly rising as it spreads towards the west. Its boundary in the latter direction presents a very irregular winding line, along which the marl and the primary rocks are seen alternately encroaching each upon the general limits of the other. Indeed at some points insulated patches or ridges of the former are seen rising through the marl at a short distance from its western limits, while at others little nooks or basins of the marl occur almost completely encircled by the primary rocks. In a word, the form of the curiously broken line which constitutes the boundary of the two is just such as might be expected from considering it as marking the indented outline of a low rocky coast, washed by the tides of the primeval sea, beneath whose waters were slowly accumulated the successive deposits of shells and sand and clay, now forming the wide tract of land spreading eastward to the present margin of the ocean.

Excepting in the tracts lying near the eastern and western boundaries of this plateau, the surface strata are horizontal and composed of sands and clays of a fine texture, rarely intermixed with pebbles of considerable magnitude. Unless in the immediate vicinity of the rivers, ravines are rarely met with, and even bordering on the streams

the land gradually declines to the level of the water, or what is still more common, slopes gently down to the surface of a narrow flat through which the river finds its channel. Though as before remarked, the uniform level of this wide plain is in general maintained with but slight variations, there occur several low ridges and insulated hills, having a northeasterly and southwesterly direction, but never attaining an elevation to render them conspicuous in the topography of the country. Of these there are two particularly interesting from their height and the light they reflect upon the relations of the several subdivisions of the Tertiary formation, the one stretching over the Nottoway river near the mouth of Nottoway swamp, across the tract intervening between that stream and the Blackwater, and following the direction of the latter, chiefly on its western side, the other extending in a nearly parallel direction a little west of the Nottoway, and intersecting Three creek, Racoon creek, and Hunting quarter. The former of these low hills presenting on its eastern declivity an abrupt and on its western a gentle slope, attains a height usually from 20 to 30 feet above the level of the surrounding country; the latter rises in some places to perhaps a greater elevation.

As already intimated, the usually unbroken character of the plain of which I am treating, is not preserved in the tracts adjoining its eastern and western margins. Along the former the high grounds overlooking the extensive flats spreading off towards the Atlantic, are deeply channelled by numerous and abrupt ravines, widening and deepening as they approach the lower plain. Above and along the sides of these the surface stratum, composed of coarse gravel and pebbles, often extending to a considerable depth, and arranged in layers frequently inclined at a steep angle, is seen resting upon the marl at various elevations, sometimes filling a cavity which is but the section of a ravine or trench formed by the removal of a portion of the shelly stratum before the coarse sand and gravel was poured in, sometimes occupying a conical hollow or pot hole penetrating many feet below the surface of the marl, and sometimes blending itself with the fragments of broken shells, such as compose the underlying strata. In a word, the coarseness of these materials, so different from the superficial beds in the middle portions of the tract, their steep and varying inclinations, and the deeply furrowed surface upon which they rest, combine in proving that along this margin of the plateau at one time, tides or currents, or most probably both, operated with great force, and that while as yet the lower plain situated towards the east had not emerged from the ocean, this irregular escarpment of the higher level formed the barrier to the waves. Nor should it be deemed an unimportant fact, in confirmation of this view, that along this line the beds of marl, especially the upper strata, are every where composed of *fragments of shells*, often reduced to a mere shelly sand, and by a spontaneous process cemented into a species of fragmentary limestone.

Analogous phenomena are presented in the surface strata of the western margin of the plateau, where it spreads along the base of the low ridge of primary and other rocks bounding it on the west. Here we

meet with a gravel of great coarseness often containing well rounded masses many inches in diameter, and all derived from the rocky strata situated to the west. These beds of sand and gravel of every variety of texture, as disclosed in the ravines, or in artificial sections, display the same obliquity and frequent changes of direction in their component layers which were before noticed, but in a still more remarkable degree—and thus according to the observed and well known effects of currents, establish the fact that along this line of boundary, and for some distance to the east, the agencies of tides and currents must at some former time have operated with great violence and effect. It may not be uninteresting to add, that the same evidences of an ancient coast line along which are seen the rocky fragments transported by wide rivers or sweeping inundations coming from the west, are found continually accompanying the narrow belt adjoining the primary rocks on the east, not only in its course entirely across our state, but through Maryland, Pennsylvania and New Jersey. And I may further say, that owing to the more level surface of this than the adjoining rocky district to the west, as well as the yielding nature of the surface strata, the great line of rail-ways now nearly completed from Carolina to the the northeastern extremity of New Jersey, pursues with but few and short deviations the direction of this belt—thus affording to the traveller frequent opportunities of observing striking indications of the operations of those energetic currents which were once in motion along this ancient line of coast.

It would thus appear from the topographical and other features that have been described, that since the waters of the Atlantic flowed up to the base of the rocky ledge now marked by the lowest falls of our great rivers, entering its various coves and indentations, and giving opportunity for the gradual accumulation there, as well as farther east, or more out from the shore, of the various strata of marl and other marine deposits found in their positions at the present day, at least two important geological changes have occurred.

Of these changes, forming epochs in the physical history of this portion of our state, and I may add, of a wide territory beyond it towards the northeast and south, the first must obviously have consisted in a change in the position of the extensive tract adjoining the primary, and comprising the upper plateau above described, by which from being the bed of the ocean, it was converted into dry land—the second, in a like change, by which the lower tract was relieved of the incumbent waters. By the first, the coast line was transferred from the edge of the primary rocks to the eastern escarpment of the higher plateau—by the second, from that escarpment to the present margin of the sea. It would be inappropriate here to discuss the question, whether these changes were brought about by a subsidence or retreat of the ocean, or by an elevation of the land, though local facts are not wanting in favour of the latter of these views in preference to the former—and in the view of geologists, to whom changes of this kind, in progress at the present day, as well as of ancient occurrence, are among familiar phenomena, it will scarcely be regarded as admitting *of dispute.* That these changes were rather abrupt than gradual,

would seem to be evinced by the nearly uniform level over the surface of each plateau, and the very sudden alteration of level at the western boundary of each—neither of which could be anticipated under the influence of a slowly progressive change in the relative level of land and water—causing, as it would, a gradual transfer of the coast line so as to cover successively every portion of both tracts, and creating a *gently shelving* surface from their western boundary to the sea.

CHAP. 2.

Probable extent to which the Marl is spread out.

The entire area of the two planes above described may be estimated in round numbers at about 3000 square miles, from which for the present, deducting that portion of the surface occupied by the counties of Norfolk and Princess Anne, within which the beds of Tertiary marl, though as there is reason to believe continued beneath, have as yet been reached only at one or two points, there will remain upwards of 2000 square miles of territory on the south side of James river underlaid extensively, if not uninterruptedly, by the shelly strata. The perfect continuity of these subjacent beds throughout the wide tract whose area has been mentioned, it would obviously be impossible to demonstrate—nor, judging by analogy, is it likely that such would be the condition presented by them were it possible to lay bare the level at which they repose. We might rather expect to find them overspreading numerous areas of greater or less extent, separated by spaces in which few or no shells had been deposited—while in some cases, at still greater depths, the spaces barren above would be found occupied by beds of marl, and the higher marl beds underlaid by unproductive sands and clays. But though these variations in the character of the subjacent strata may with reason be inferred to exist, the multiplied observations made in all parts of this region where exposures of marl, either natural or artificial, could be met with, concur in shewing that with but inconsiderable differences as to depth below the general level of the plain, deposits of marl may be anticipated, if not at every spot, in every neighbourhood of any considerable extent. As examined along the Blackwater, Nottoway and Meherrin rivers, and their numerous tributaries, both great and small, as well as at various points where exposures were presented at some distance from the streams, great general uniformity was observed both in the characters of the several strata of marl reposing in succession one upon the other, and in the depth below the common level of the surface of the surrounding plain, at which each of the respective layers was placed. That in many portions of this tract, remote from the chief rivers by which it is intersected, few or no natural developments of the shelly strata should have been discovered, admits of easy explanation, when we bear in mind that excepting towards its eastern margin, and in the vicinity of streams, the uniform level of the surface is never interrupted

by deep ravines, and that the shallow trenches occasionally occurring penetrate too little beneath the surface to reach the common level at which the marl is usually found.

High up along the Nansemond river, and along the Blackwater, Nottoway and Meherrin, as well as their branches, a striking constancy is remarked in the position of that portion of the series of marl deposits called the blue marl, the lowest of the series as exposed in this and other parts of the area occupied by the Miocene Tertiary of the state. At almost every point where it has been examined, excepting along the eastern limits of the plateau, where it gently dips beneath the level of the tide, not again to appear at the surface, this stratum may be seen skirting the water line in a slightly undulating band, and rarely rising to the height of many feet above the stream. In the southern portion of the tract this feature is most uniformly displayed, while near to the James river a decided rise of the strata may be discerned as we trace them westwards—thus bringing the blue marl and the incumbent portions of the series, where preserved, to a greater elevation above the level of the water—a feature yet more distinctly marked in the Tertiary districts lying north of the James river. The general parallelism thus maintained between the plane of the marl and that of the rivers throughout most parts of the southern tract, distinctly indicates a gentle declination of the marl in a southerly direction, or that in which the Blackwater, Nottoway and Meherrin flow—and indeed it might with some reason be maintained, that the sloping of these beds in that direction, as well as the comparatively unyielding nature of the tenacious clays of which they are principally made up, have exerted an important agency in determining the drainage in that direction, as well as in preventing the streams from forming a deeper channel than is furnished a few feet below the upper surface of these beds.

It will be inferred from these remarks, that throughout most of the area of which I am treating, the blue marl cannot be reached at depths much less than that of the level of the principal stream, and that explorations should never be regarded as unsuccessful until that depth has been attained. It may, I think, also be inferred from the peculiar uniformity of position and character of these beds, that a very general, though not uninterrupted expansion of them would be found spreading away from the margins of the streams to pass beneath the highlands in which, from their level topography, no exposures have yet been found. Nor can it be admitted as presenting an objection to this very pleasing deduction from the facts observed, that no such general continuity of the strata is met with along the southern shore of the James river in tracing the Miocene marl from its most eastern to its most western exposure, comprising a breadth east and west of about 40 miles. The immediate basin of this river often presents for many continuous miles along the margin of the water, and even to some distance inland, deposits of sand and clay unmixed with shells, evincing in many places by the vegetable remains and other alluvial relics they enclose, that they belong not to the Tertiary formation, but owe their existence to the transporting and accumulating labour of the stream

itself, in periods subsequent to that in which the Tertiary plain became dry land. The bluff-like line of hills by which we ascend from these flats to the level of the Tertiary plateau, are the true margin of the formation, as they would appear also to have been once the barriers that confined the ampler volume of waters that through the broad and winding channel wrought across the Tertiary plain found their passage to the ocean. Indeed, as observed in a former report, very inadequate ideas would be formed of the continuity and extent of the marl strata, from observations on any of our great rivers, and to none is this remark more applicable than that which forms the northern boundary of the tract of which I am treating.

Of the probability that the marl is continued eastward beneath some parts at least of the low plain of Norfolk and Princess Anne counties, incidental mention has already been made, and the reasons for entertaining such a hope may not inappropriately be presented at this time. Lest, however, too sanguine expectations should be indulged of realizing so interesting a conjecture, it is proper to remark, that though diligent enquiry, aided by shallow borings at several places, was made throughout this region, and along the canal and feeder and at other points within the Dismal swamp, no unequivocal deposit has yet been found excepting in the vicinity of the Great Bridge in Norfolk county, and four and a half miles northeast of Suffolk near the western margin of the swamp. Of these the latter consists of blue marl, identical in character with the upper portion of that formation west. The former was of more ambiguous character, and for want of a sufficient variety of shells cannot yet be decidedly referred to a place in either of the members of the Miocene Tertiary hereafter to be described.

I have already stated that along the eastern escarpment of the Tertiary plateau, the blue marl, where in view, is observed to dip gently though irregularly in a direction which would carry it beneath the low plain lying towards the sea—and as might be expected, the overlying marly strata incline in a corresponding direction. Thus in tracing these beds as exposed on the shores of the Nansemond river, from the mouth of Bennet's creek, where they first appear, up towards Suffolk, the first exposures as they emerge above the water line are observed to consist of the fragmentary and yellowish marls, known to be higher in position than the blue. But bending westward, as we ascend, we observe the blue marl rising into view in the neighbourhood of Sleepy Hole ferry, and after emerging a little higher, continuing generally exposed to the height of a few feet above the water line, throughout the reach of the river below Suffolk, having a north and south direction. So also at Day's Point, the most eastern exposure of marl immediately on the southern bank of James river, the shelly stratum that first emerges from the beach, at a short distance above the mouth of Pagan creek, consisting of the overlying bed of ferruginous marl, is seen gradually rising to a higher level as we ascend the river, until about a quarter of a mile above and in a direction N. W. from the point at which the marl first came in view, we see the blue stratum beginning to shew itself beneath the other, and soon with a gentle slope rising to the height of several feet above the base of the river bank.

This general declination towards the south and east, along the margin of the higher plateau, as well as throughout its whole extent, as formerly remarked upon, can hardly fail to be regarded as favouring the opinion that the lower of these beds, to wit, the blue marl, is continued seaward beneath the contiguous flats, and though probably in general with increasing depth as it stretches towards the ocean, not too much removed from the surface to be accessible by moderate excavations along the eastern portion of this lower plain. But of the persistency of the upper light coloured beds of the marl beneath this tract, the probability is far less, as those destroying agencies, whether of tides or currents, whose traces are so deeply impressed along the ragged and channelled escarpment of the higher plateau, could hardly have spared these more superficial and less resisting materials.

Whether the shelly strata in question, should they exist beneath this tract, are within such a distance of the surface of any considerable portion of its area as to render the requisite excavations sufficiently cheap to be of economical advantage, can only be determined by a systematic exploration by means of borings at numerous places, carried to a considerable depth. These, from the attendant expense, and the time they would consume, I have not felt justified in undertaking in connection with the survey, more especially too, as with some combination of effort among neighbouring proprietors, this simple operation could be conducted as successfully by the persons immediately interested as by myself or any of the members of the corps. I cannot however dismiss this topic without suggesting the expediency of such borings in various places throughout the western portion of this tract, and tendering such assistance and advice as it may be in my power to give to those who may feel disposed to enter upon such an experiment. I would further suggest, that the probability of the existence of the marl throughout a portion of this tract does not appear to me the less from the absence of marl beds in the deep excavations made at the navy yard and dry dock in the vicinity of Portsmouth, for from the character of the strata there penetrated, they would seem to have originated as deposits from the neighbouring rivers, not likely to extend inland to any great distance, or should they be of more general occurrence, they might perhaps prove to be strata overlying the marl—in which event, however, its depth throughout that neighbourhood at least would render it unavailing for any useful purpose.

CHAP. 3.

Of the Position and Limits of the Eocene Tertiary as presented in the Tract South of the James River.

The existence of strata appertaining to this the lowest and most ancient division of the Tertiary formation along the James river, as well as at a few points lying towards the south, was announced in the report of the geological reconnoissance of the state, and at the same time some details were given in regard to its character, as well as that of the overlying Miocene, as observed at several interesting localities on

the southern bank of the river. Since that time, as will be seen by reference to succeeding reports, its boundaries have been traced to the Potomac, and the characters of the various beds of which it is composed, in regard to mineral and fossil contents, as well as agricultural efficacy, has been made the subject of minute examination. Still more recently the limits of this formation, as exposed on the James river, and traced southwards until it ceases to be revealed either in natural or artificial sections of the country, have been attentively explored. Of the general results of these observations, the following brief sketch will, it is thought, be deemed sufficient for the present.

In tracing the Miocene marl westwards by the numerous interrupted exposures in which it is disclosed along the southern bank of the James river, after passing a point a little above the mouth of Chipoak's creek, the strata contiguous to the river, and generally for some distance inland, are found to consist of sands and clays devoid of shells or their impressions, plainly referring themselves to the more recent class of deposits due in great part to the operations of the stream, and to that diluvial rush of waters, of whose agency numerous evidences are met with throughout the Tertiary plain. This feature is maintained along the shore as far as a point about $\frac{3}{4}$ths of a mile below the mouth of Powell's creek, though at some distance inland both north and south of the river, as might be expected, exposures of the true Miocene marl are met with.

At the point just mentioned, the Eocene first makes its appearance in the base of the river bank, extending along the shore only for a short distance. It is of a light colour, quite indurated, containing impressions of shells, and occasionally an Eocene oyster. With some interruptions it may be traced westwards to near the mouth of the creek, gradually rising until it reaches a height of about three feet. Throughout this line of exposures, the shelly stratum is generally overlaid by a ferruginous band from 8 to 18 inches in thickness, containing at many points small crystals of selenite or crystalized gypsum. This gypseous bed is covered by a layer composed almost entirely of pebbles, which may be regarded as marking the upper boundary of the Eocene, and upon this reposes a bed of pipe clay; the Miocene strata, seen at other points inland, as well as above on the river shore, having been removed in this vicinity by local agencies.

Still higher up, at Coggin's Point, Tarbay and Evergreen, the beds of Eocene are observed emerging to a greater elevation, and from the height of the river cliffs at several places, an opportunity is afforded of viewing the incumbent beds of Miocene in the upper parts of the same exposure in which the Eocene is seen below. Of the principal features remarked at these interesting localities, some account having been given in a former report, their further and more detailed consideration will be omitted for the present. Still pursuing our course upwards along the river shore, we find numerous interrupted exposures. At City Point it is seen for a distance of several hundred yards rising a few feet above the base of the bank, presenting a dark brownish green colour, a sandy, micaceous and slightly tenaceous

texture, and containing a slight intermixture of sulphate of iron and gypsum, and impressions of shells, with little or no shelly matter. The green sand to which it owes its colour, besides being generally diffused, is seen occasionally collected into spots. Here, as at most of the other localities, the greenish stratum is overlaid by ferruginous clays and a gravelly bed, often assuming the character of a coarse ferruginous sandstone. Similar appearances are presented by these beds, as disclosed on the opposite side of the river at Herring creek, Berkeley, Shirley and other places, the lower stratum of a dark green colour being found to extend to the depth of many feet below the base of the bank, containing a considerable proportion of green sand, and abounding in impressions of shells, while the upper beds of the Eocene, where exposed along Herring creek, present a good proportion of shells in an undecomposed condition. At Mr. Archer's and Mr. Allen's above Bermuda Hundred, the lowest strata of the formation are displayed at numerous places along the river shores, containing a few unchanged shells, and abounding particularly at the latter place in casts of the turreted shell usually found near the bottom of the formation. At Deephole, the most western exposure of the Eocene, immediately on the river, the marly bed consisting of an indurated light coloured calcareous clay, abounding in casts of the shell just referred to, after continuing at a level of 2 or 3 feet above the surface for a short distance up the river, is seen to rise at a considerable angle, until its lower boundary emerging from the base of the river bank, discloses a stratum of decomposing *micaceous sandstone.*

Here terminates the series of Tertiary deposits, so far as disclosed along the river. The sandstone in question marking the upper limit of a formation which is irregularly extended over the granite and other primary rocks in this and the more northern portion of the state in the same meridian, refers itself by the fossils it contains, as well as by its position, to a class of deposits of more ancient formation than any of the *Tertiary group*, and is clearly ascertained to belong to the later of the *secondary class* of rocks, being not widely separated in the series from the strata of sandstones and slates associated with the coal of Chesterfield, Powhatan, Henrico and Goochland counties. The upper surface of this sandstone formation, worn and broken in a very irregular manner, and not unfrequently covered with a layer of coarse pebbles, bears witness to the destroying energy of the currents which swept over it prior to the commencement of the Tertiary deposits, and thus marks an epoch of violence in the early geological history of this region. It is on this account that these sandstones display remarkable irregularity as to thickness and texture, as displayed at intervals higher up the river, and in some parts of the belt over which they are generally spread out, they appear to have been entirely removed, permitting the lower Tertiary beds to rest immediately upon the granite.

South of the James river this irregularity in the subjacent secondary sandstone is much more strongly marked than in the northern portion of the belt as it extends with a variably increasing breadth across the South and North Anna and Rappahannock rivers as far as the Poto-

mac. Hence, as might be inferred, the limits of the Tertiary beds towards the west, or where they join this older formation, present the most complicated sinuosities. Indeed islands and peninsulas of the sandstone are met with some distance eastward of its general boundary, while inlets of the Tertiary strata are seen penetrating beyond it to the west. Thus on a branch of the Appomattox just above the fork near Broadway, on a meridian several miles to the east of that of Petersburg, these layers of coarse and fine sandstones and conglomerates are seen lying horizontally one upon the other, forming a cliff about fifty feet in height, while in the vicinity of Petersburg the greenish sandy strata of the Eocene are found. It may well be imagined therefore, that near its western margin the usual continuity of the Tertiary marl formation will be liable to frequent and sudden interruptions, and that from its existence on one estate no argument can be drawn for its presence on that which lies contiguous and in the same meridian.

This belt of sandstones, forming farther north so important a feature in the geology of the western confines of the Tertiary tract, continues but a short distance south of the James river. Suddenly terminating, so far as superficial exposures are concerned, on the Appomattox in the vicinity of Petersburg, no indications of it are met with further south in its previous position, between the Tertiary strata and the ledge of primary rocks, and only in one instance has a rock resembling it been found in the country lying south of the neighbourhood of Petersburg. Neither, as far as I know, does it make its appearance in North Carolina. The insulated locality just referred to, is in the bed of the Nottoway river about 4 miles above Bolling's bridge, where a rock forming the natural foundation of a bridge, is exposed for a short distance nearly on a level with the water, bearing a close resemblance to the formation referred to, and which there is strong reason for believing is geologically the same. From the small area occupied by these sandstones on the surface of the tract south of the James river as well as the frequent overlapping of the Tertiary beds, I did not deem it important in describing under a preceding head the general character of the western boundary of the upper Tertiary plain, to advert to the small thickness of these rocks interposed between the marl and the ledge of primary. Nor indeed in any part of the state is such a reference necessary in fixing the general limit of the Tertiary in this direction, since every where throughout their range we find these sandstones more or less overlaid by the marl, and permitting the close approach and not unfrequently the contact of the latter with the primary. But in tracing more in detail the boundaries of the Eocene or Tertiary marl, I have deemed it not uninteresting in an economical as well as geological point of view, to present the reader with an explanation of the irregular manner in which the Tertiary strata may be expected to occur every where in the vicinity of the sandstone formation.

It will be inferred from the preceding remarks that throughout most of the Tertiary tract, south of the James river, the true line of termination for the marl is at the commencement of the primary rocks, though as formerly stated, this line is scarcely less inflected and irre-

gular than that which marks the contact of the marl with the sandstones. As examples of this irregularity, cited formerly in a general way, I may point the reader to a locality on the Nottoway near the mouth of Harry's swamp, and between 3 and 4 miles higher up than the spot in which the solitary exposure of sandstone occurs, and to several points in the neighbourhood of Hick's ford—at all of which we find granite or other primary rocks rising through the marl, thus affording exposures of the latter to the west as well as to the east of the former. Without entering into details illustrating the more important flexures of this boundary line, it will suffice for the present to indicate the general margin of the Tertiary by a straight line connecting Petersburg and Hick's ford, and thence continued to the state line.

It might be expected from the continuity of the Eocene strata, as heretofore carefully traced from the Potomac to the James river, that they would be found prolonged as a continuation of the same belt, lying at the foot of the Tertiary ridge, throughout the tract lying southward of that river. But though as already described, they shew themselves on the southern bank of the river, lying beneath the Miocene, from a point a little below Powell's creek in Prince George, to Deep hole in Chesterfield—thus occupying a width from east to west of not less than 15 miles—and though as far south as a line drawn a little south of Petersburg they are still met with near the water level, yet throughout the remainder of the Tertiary tract lying in the direction of this Eocene belt, no unequivocal indications of the continuation of this lower member of the Tertiary series can be found. At a single locality within this tract, immediately contiguous to the exposure of sandstone previously mentioned as occurring on the Nottoway above Bolling's bridge, a nodular and highly calcareous material was some years ago met with in digging a small canal. This in general aspect and composition bears a striking resemblance to the calcareous concretions often found embedded in the Eocene, but from the want of fossil impressions on these masses, it would be impossible to infer with confidence to what division of the Tertiary they belong. As, however, from their position where met with, they were evidently from a stratum resting on the sandstone shewn at contiguous points—and as this is almost certainly in a geological sense the same with the sandstone immediately underlying the Eocene on the James river and in other parts of the state, it may be inferred as highly probable that the calcareous material in question is the representative of that portion of the Tertiary in the region where it was found.

It would appear, therefore, from all that has been said on this subject, that both the sandstone and the Eocene Tertiary, if prolonged continuously towards the south, must lie at a depth that places them beyond the reach of the excavating power of the streams. Bearing in mind the interesting fact referred to under a former head, that throughout this portion of the upper Tertiary plain, the blue marl, a higher formation than the Eocene, preserves a nearly uniform level of a few feet above the water line of the rivers, it could not be expected that the latter should be reached by any of the natural excavations of the country, much less that the underlying sandstone should make its ap-

pearance on the river banks. It is moreover worthy of observation as regards the question now in view, as well as the fact of the comparatively gentle slope and shallow channels of the three principal streams intersecting this region, that while in common with the James, York and Rappahannock rivers they flow from a belt of very uniform elevation, immediately below the falls, and terminate their course at an unvarying level to the east, the three streams in question are compelled, by the direction they pursue, to traverse a much greater actual distance in making the same approach as the others to the ocean level.

CHAP. 4.

Order of the Strata in this Region from the Granite up.

Having, by the descriptions above given, furnished the reader with the means of clearly marking on the map the general divisions of the Tertiary plain south of the James river, and of forming correct views as regards the positions and relations of the principal groups of strata within its limits, I proceed to a brief account of the arrangement in which those groups occur, with the view more particularly of drawing attention to the subdivisions of the Miocene Tertiary, which, wherever presented, have been found distinguished by well marked peculiarities.

To aid the reader in acquiring clear conceptions of the order in which the several strata of this region, wherever met with, have been found to be arranged, as well as of the appearances presented at the plains of junction of the several groups or formations, indicative of intervening periods marked by the wearing or denuding action of water, I have constructed the following column or vertical section of the strata from the surface of the primary, which was antecedent to them all, to that of the soil, which is the most recent and covers them at top.

In this column it will be seen, that between the primary rocks and the blue marl, or lowest of the Miocene beds, both the secondary sandstone and the Eocene are interposed, although their presence in a large portion of the region south of the James river is to be regarded as only a somewhat probable inference, not a demonstrated fact. In this particular, therefore, the representation is to be looked upon as applying with undoubted accuracy, only to that portion of the tract lying along and near the James river, at the same time that it is also a faithful picture of the whole series of formations as observed in the region north of the river.

It should further be borne in mind, that though the succession of strata, as to time and order of superposition, is faithfully indicated by the figure, the whole of the series of formations which it comprises are not to be looked for at any one locality. Thus, while near the western margin of the tract we may at some points be able to discover the primary, the sandstone, the Eocene, and perhaps the lower portion of the Miocene, invariably resting the one upon the other, in the order in which they have been enumerated, farther to the east we will meet

with the remainder of the series, including the blue and yellow and fragmentary marls, the overlying horizontal clays and sands, and the coarser diluvial material immediately subjacent to the soil, so that by connecting such observations, made at different points, through the medium of some one stratum whose established identity enables us to employ it as *a link*, we are enabled to construct the entire column of formations in the order in which they were deposited.

EXPLANATION OF THE GEOLOGICAL COLUMN.

A to B—Represents the beds of sand and gravel, usually lying immediately below the soil, which from their oblique position and the general coarseness of the materials, indicate a deposition under the influence of strong currents. This overspreading the region extensively, and evidently due to some general cause, is properly to be regarded as *Diluvium.*

B to C—Horizontal beds of sand and clay, prior to the diluvium, and partially and sometimes entirely removed at the time of its deposition.

C to D—*Upper* portion of the *Yellow marl*—a conglomerate of fragments—containing in its lower parts, nearly entire, but water-worn shells.

D to E—*Lower* portion of the *Yellow marl*—shells contained in a friable sand, and near the bottom in a tenacious clay—numerous species above, mactra modicella almost entirely beneath.

E to F—*Upper Blue marl*—a blue clay of fine texture—rich in mactra mod.—shells becoming more various as we descend.

F to G—*Lower Blue marl*—a more sandy material—abounding both in the number and variety of its shells.

G—Thin band of pebbles, separating the Miocene from the Eocene Tertiary.

G to H—*Eocene* on the James river—clays and sands usually of a greenish tinge—containing shells and their impressions—often presenting a considerable proportion of green sand and some gypsum.

H to I—*Sandstone formation*—deeply channelled above—before the deposition of the Eocene.

I to K—*Granite* and other primary rocks, upon which the sandstone rests.

Referring to the lower part of this geological column, in which the secondary sandstone is represented as resting on the granite, it is proper to remark that though *in this region* no rocks more ancient than the sandstone are interposed between it and the irregular floor of primary upon which it lies, it would be inconsistent with a more extended observation of facts to infer from this that the deposition of these sandstones constituted the next important geological event, after the elevation of the granite to the position which it now occupies. So far is such an inference from being correct, that upon a wide survey and comparison of the rocks in other parts of the state, no doubt can be entertained that all the groups of limestones, sandstones, slates, shales and coal seams occupying the wide region lying to the west of our Blue Ridge, are of greatly higher antiquity than the secondary sandstones here referred to, and were the geological column complete in the tract of which I am now treating, these Appalachian and Alleghany rocks, comprising a thickness of strata of many thousand feet, would form but a portion of the formations which would be found interposed between the primary rocks and the secondary sandstones here lying as indicated in the column in immediate contact. Nor is there any thing to excite surprise in the existence of a hiatus of such vast extent in the series of geological formations. Throughout a large portion of our state lying between the head of tide and the crest of the Blue Ridge, the primary rocks occupy the surface to the exclusion of all others, being simply covered by the thin stratum of soil to which they have given origin by their decomposition, thus bringing into immediate juxtaposition materials appertaining to the most ancient and to modern geological productions. That this portion of the area of primary rocks, as well as that upon which the secondary sandstone in question reposes, were not covered by deposits such as are found west of the Blue Ridge, only serves to shew that at the time in which the Appalachian and Alleghany rocks were progressively forming beneath the bed of the wide ocean whose waters extended from our Blue Ridge over the great valley of the west, the primary surface on this side was not in a position to receive these depositions; in other words, it was then, as the most of it is now, dry land. Along its eastern margin, however, and over some breadth of the primary in the northern portion of the tract, as extending in a direction to intersect our principal rivers near the head of tide, at a much later period than that of the production of the formations west of the Blue Ridge, this primary surface was in a situation to receive the sedimentary material of which the secondary sandstones in question are composed, a material bearing evidence in its mineral nature, and the large proportion of water worn pebbles it frequently contains, as well as in the character of the organic relics by which in many places it is abundantly impressed, that the scene of its production was one in which marine and terrestrial agencies were combined, the margin of a broad estuary or a shallow sea.

Looking now to the group of Eocene strata resting on the surface of this sandstone, where the latter is present, we perceive in the undulating line of contact which so generally marks the junction of the

two, and in the accumulation of coarse gravel near the upper limits of the sandstone, that previous to the commencement of the Eocene deposits, the subjacent rocks were deeply trenched, and sometimes almost entirely removed by powerful currents sweeping over their surface, bearing away the finer materials of these rocks, and pouring into the cavities thus formed the coarse gravel and pebbles too ponderous to be removed. We see too in this rugged boundary, as thus simply depicted to the eye, and that with far more distinctness than could be communicated by mere words, how great must be the irregularity before adverted to, in the outline of the Eocene tract on the surface of the Tertiary plain where it adjoins these sandstones, and hence we derive a strong impression of the necessity of minute individual research along the confines of the two, in deciding upon the presence or absence of the Eocene marl in neighbourhoods where it may be desired to bring it into use.

Ascending in the column to the next group of strata, we find the Miocene Tertiary separated from the Eocene by a band of pebbles or coarse sand, which, though not always present, is very generally met with in this place. These pebbles, as observed at numerous points on the Potomac, Rappahannock and Pamunkey, and less abundantly on James river, are remarkable for their black colour, and are found more or less diffused for some distance through the upper and lower beds. Here too is very commonly met with a ferruginous stratum, sometimes having the hardness of a rock, consisting usually of coarse sand and some pebbles, cemented by oxide of iron. But along this bounding plain, which separates the Eocene from the Miocene divisions of our Tertiary, excepting this thin band of comparatively coarse material, we observe no evidences of physical violence having intervened between the close of the Eocene and the commencement of the Miocene deposits. None of that trenched and channelled configuration of surface remarked in the sandstone is here met with, but the smooth and unbroken level of the Eocene, washed by a gentle current just sufficing to develope the thin pebbly band referred to, became the recipient of the successive strata of the overlying Miocene.

Yet though such slight marks of violent agencies are perceived in the interval between the two formations, so far as they are exposed in Virginia, it is interesting to observe how great a change took place in the character of the deposits when the Miocene strata began to be formed. The green sand, comparatively so abundant in some of the Eocene beds, and thence imparting to them the deep greenish colour for which they are distinguished, is scattered much more sparingly through the Miocene strata, and is often scarcely to be discerned at all, while the relics of organic life, consisting chiefly of shells, met with in such numbers in the Eocene, are with perhaps a single exception discontinued in the overlying formation, to make way for a far greater variety of species, distinct from those below. It is indeed a remarkable fact, that, one doubtful case excepted, no shells have been met with in Virginia common to the two formations, and that the *inspection of a single shell* will therefore enable the observer confi-

dently to pronounce upon the character of the stratum whence it was taken, whether as pertaining to the Eocene or Miocene division of the Tertiary. It has been for want of such a relic, or the cast of it, in the calcareous concretionary material formerly noticed as occurring above Bolling's bridge on the Nottoway, that I have been thus far unable to form a decided opinion as to the presence of the Eocene in that region, and the discovery of only a solitary shell or its impression may, by removing existing doubts, furnish a motive for exploring beneath the blue marl in some portions of that district for beds of Eocene that at some future day may become of economical importance. Those who, misconceiving the objects the geological explorer has in view in collecting and scrutinizing with so much care the shells and other fossil relics of our marl beds and other strata, are disposed to regard his labour and attention as at best bestowed to gratify a scientific but useless curiosity, will perceive in the facts here stated a striking illustration of the practical results which such enquiries not unfrequently unfold.

To what cause we are to ascribe this remarkable fact of the almost entire change in the species of shellfish inhabiting the Tertiary sea, in passing from the Eocene to the Miocene formation, is a question by no means easy of solution. The seemingly almost quiet transition from the one series to the other, precludes the supposition of any violent convulsion by which the former races might have been extinguished, and new conditions of the ocean and its sediments induced favourable to the increase of the various new species which flourished during the period when the Miocene beds were forming. Yet as such a change in the sedimentary matter is seen to have taken place along with the introduction of this new population in the bed of the ocean, there can be no doubt that some important physical revolution intervened between the Eocene and Miocene, for the distinct marks of whose violence we are perhaps to look to other and distant regions in which these divisions of the Tertiary are developed, and of the occurrence of some such, geologists abroad have already become aware.

The Miocene strata thus broadly distinguished from the Tertiary beds beneath present, where entire, the three sub-divisions represented in the column, to wit: the blue marl, the yellow and grey marl, and horizontal beds of fine sand and clay, of which I shall now proceed to treat in the order enumerated.

Of the Blue Marl. The strata here referred to as occupying the lowest position in the Miocene group, are distinguished by their dark bluish colour when moist, which turns to a bluish grey on drying, and by being composed of a very fine homogeneous clay of a soapy feel, especially when wet. Towards its lower limit, approaching the Eocene, the texture of the clay becomes coarser and less tenacious from the presence of a considerable amount of gritty sand, and near the bottom and sometimes even throughout a considerable part of its thick ness, the sandy character is found to predominate. The shells and other fossils it contains, though generally embedded closely together, are sometimes very thinly disseminated through the stratum, and in

almost every case are in beautiful preservation, and free from the marks of violence met with in the fossils of some of the overlying beds. They are of very numerous species, associated in some cases with fragments of zoophytes resembling corals. This variety of species, however, is chiefly displayed in the lower portions of the strata, and is more remarkable in the exposures in the middle and western parts of the Tertiary tract than near its eastern margin. The upper portions are remarkable throughout a large extent of this region for containing a single species of shell, almost to the exclusion of the rest, and often in such great numbers as to form more than half the entire weight of the material. This beautiful little fossil (the Mactra Modicella) is a bivalve or shell consisting of two nearly equal and similar parts, of an oval figure, about three fourths of an inch in length and three fifths in breadth. Though less abundant in the lower parts of the blue marl than near the top, it is still found in considerable numbers, mingling with the other fossils, and may be regarded as characteristic of this and the next superior part of the Miocene throughout this portion of the state. In a large number of cases, these shells are found with their two valves in their natural closed position, the interstices being filled usually with the same fine bluish clay that surrounds them. When disjoined, as well as in the state just mentioned, the valves are perfect in all their parts, retaining unbroken the most delicate processes and margins, and in general still covered with the pearly coating that naturally invests them. They are, moreover, seen to be arranged in layers or groups in the enclosing clay, and from this and the other facts just stated, may be confidently regarded as occupying the very positions in which the successive generations of animals who dwelt in them lived and died.

This great predominance of the fossil in question is less generally observed as we trace the upper layer of blue marl towards the west. There the mactra is found to be more largely intermixed with other shells, so that the distinction of this stratum from those beneath is nearly or altogether lost.

As formerly mentioned, the blue marl is met with at a very uniform level, of a few feet above the surface of the principal streams, in all parts of the district excepting along its southeastern margin, where it descends with an inclination towards the east and south, so as to disappear below the water.

The general direction of this line of intersection of the upper surface of the blue marl with the water plain, may be indicated by an irregularly inflected margin, commencing at Day's Point on the James river, at the locality formerly mentioned, a short distance above the mouth of Pagan creek, crossing this creek in the neighbourhood of Smithfield, intersecting Chuckatuck a little below the mill, touching the Nansemond river a little below Sleepy Hole ferry, then taking a nearly meridianal direction which carries it west of the river, crossing Western branch near its mouth, and pursuing the direction of the river to the vicinity of Suffolk. Gradually bending towards the west, the line in question now strikes across to the Blackwater river, on the margin of which at a point a little below M'Clenna's bridge, the blue

marl is seen nearly on a level with the water, and continuing in the same general course, it crosses the Nottoway a short distance below Monroe, and thence passing to the Meherrin river intersects that stream a little south of the state line and near the mouth of Flat swamp. The boundary thus indicated will of course be subject to some variation according to the fluctuations in the level of the water plain to which it is referred. So that from the near parallelism of the marl and that plain, a few feet of rise or fall of the water may conceal or disclose the stratum for some distance above or below the average point of its emergence. Nor is it meant that the upper surface of the marl is so free from undulations of level as not at various points to cause important local flexures of this line. Yet notwithstanding this irregular and somewhat mutable character of the boundary in question, it is by no means unimportant in an economical point of view, that its general course should be delineated on the map of this region—since from such an outline a more correct judgment may be formed as to the position and depth at which the blue marl may be expected to occur.

It is important further to remark, that the tract lying to the south-east or dip side of that portion of this boundary line, which extends from the vicinity of Suffolk across the Blackwater, Nottoway and Meherrin rivers, is not to be regarded as destitute of the marl, since various facts which have come to my knowledge clearly evince its existence frequently, if not generally, along the beds of those streams for some distance south of the state line. Nor is the depth at which it is thus known to exist, within a moderate distance of the water boundary, so considerable as to place it beyond the reach of profitable exploration in such localities as are removed from these streams, and therefore less liable to the inconvenience of an influx of water sufficiently serious to obstruct the progress of excavation.

The general continuity of the blue marl through most of the upper Tertiary plain, has already been referred to as strongly indicated, if not fully established, by multiplied observations on the rivers and their tributaries throughout this region. It will therefore be apparent that notwithstanding the absence of natural exposures over many tracts of the highlands of considerable extent, as well as from local and alluvial causes, even along the margins of the rivers themselves, this extensive region is to be regarded as very bountifully supplied with this variety of the Miocene marl—and that from the generally moderate elevation of the surface of the country, few localities can be found where diggings in the ravines of from 10 to 20 feet will fail to disclose these valuable deposits.

Of the amount of calcareous matter contained in numerous varieties of the blue marl, the table hereafter to be given will convey detailed, and it is hoped, useful information.

Of the Yellow and Grey Marl. Again referring to the column, we find resting on the stratum just described, a bed, or series of beds, characterized in general by their yellowish and greyish colour, and the larger admixture of gritty sand in the earthy part of their composition. The lowest of these beds, or that resting next above the blue

marl, where exposed towards the southeastern margin of the Tertiary plain, is remarkable for its rich brownish yellow colour, is of a more clayey texture than those above, and contains the little shell (Mactra Modicella) before noticed, as so abundant in the blue of that district, to an equal extent. This fossil, though less predominant as we follow the light coloured marls towards the west, still continues to be met with in great numbers, low down in the beds, and is rarely entirely absent in any extensive exposures of them. In general towards the middle and western parts of the tract, these yellowish and grey marls increase in thickness, presenting a great variety and abundance of fossils, but the bright yellow band almost exclusively composed of the Mactra forming the lowest stratum, is thinner and less uniformly present than towards the east. Indeed, as will be seen from what was formerly stated in regard to a somewhat analogous change on the part of the blue marl as traced westward, it is evident that the line of demarcation between the two is less distinctly marked in that direction than towards the southeastern part of the formation.

In the northern portion of the tract, the thickness of these beds as exposed at numerous localities on the tributaries of the James river, is from 15 to 20, and sometimes 25 feet—the blue marl lying beneath being often met with along the base of the same hill or cliff to the depth of several feet. In a belt situated about one third of the whole breadth of the tract from its eastern boundary, the more superficial beds very frequently exhibit a mixture of greyish pulverulent or chalky marl and calcareous internal casts of shells with comparatively few shells in an unchanged state. The same peculiarity is of common occurrence over a region occupying a corresponding position in the Tertiary plain north of the James river as far as the Potomac.

The uppermost portion of these light coloured marls is in general characterized by presenting the contained fossils in a less perfect state than either the immediately subjacent beds on the blue marl, often containing along with entire specimens, a large proportion of fragments of shells. This feature is, however, but slightly displayed in the middle and most of the western parts of the Tertiary plain, but becomes very conspicuous along its eastern margin. As presented in that portion of the tract, these upper beds are almost wholly composed of fragments of shells, sometimes forming a kind of shell gravel, and sometimes sufficiently minute to be considered as a calcareous sand. Each particle or piece has the worn or rounded form that attends the continued and powerful action of water—and even the large and nearly entire shells sparingly scattered through the mass in many localities, have lost their sharp edges and pointed prominences, and in some cases, have been ground away until nothing but the central and thicker portions of the shell remain. Mingled in general with a small amount of gritty ferruginous sand, imparting to the mass a yellowish or brownish hue, this fragmentary matter is often so firmly cemented together as to have the solidity and hardness of a rock, and indeed, in this condition is to be regarded as a *Tertiary limestone.* The cementing material, as might be expected, is carbonate of lime, doubtless deposited by the infiltering water, which in its progress through

the upper portions of the fragmentary beds had become imbued with this substance, and in process of time deposited it in the interstices of the porous mass beneath, sometimes partially, at others entirely filling the vacuities of the rock. This cement, as will at once be inferred, presents in general a crystalline texture, and wherever it has filled up the hollow of a shell or any other cavity of considerable size, exhibits well marked forms of calcareous spar. As illustrating the mode in which this cementation takes place, and at the same time indicating a fact not devoid in some cases of economical interest, I may mention that wherever these fragmentary beds are exposed in considerable thickness to the inundation of tides, or to the direct access of rain, and are at the same time in the open air, as for example in the case of a cliff or river bank, though soft or but slightly cemented at first, they are seen to grow firmer from year to year, until at length the surface, and some depth of the material, assumes the consistence of a rock. In this way blocks of the fragmentary matter which have been detached from the face of the cliff in a comparatively soft state, as in the neighbourhood of Yorktown and at other places, become in time so firmly aggregated as to withstand the utmost force of the tides and waves, without any other loss of parts than would occur in the case of an ordinary limestone rock. This fact of the increased hardness of the material by exposure, has not remained unnoticed—and might perhaps, in some cases, be turned to useful account. In completing the explanation of this cementing process, it may be well to add, that the frequent or periodical exposure of the moistened mass to the air, is essential to the rapid deposition of the cement—as, in the absence of the evaporation thus produced, the infiltering water might linger long in the interstices without depositing the carbonate of lime it had imbibed, and for the most part would pass through without leaving behind it more than a trace of the matter which it held dissolved. In a word, each of these little vacant spaces presents us, in miniature, with the same changes, under circumstances strikingly analogous, as are displayed on so imposing a scale in the interior of some of our great limestone caverns, where the water that has descended through the rock, exposed to evaporation, on meeting with the air, deposits the calcareous matter it had dissolved, in a thousand beautiful and fantastic forms.

Another feature of these fragmentary beds, plainly indicating an agitated state of the waters during their deposition, is the oblique and varying directions in which the layers of fragments are laid one upon the other, while the stratum, viewed as a whole, is nearly horizontal in its position. Its component parts are arranged in their parallel bands, frequently at a high angle to the bounding surfaces of the bed, and by a similar cause, those of a higher or a lower bed are made to present an inclination in the opposite or some different direction, as if successive currents moving towards different points had dropped these fragments upon sloping surfaces, and thus adding layer upon layer, all preserving the original inclination, had gradually completed the stratum to its upper level.

As already stated, these fragmentary beds are not confined to the eastern margin of the plain, but are also found, though in far less extent, at various points approaching its western boundary.

Though frequently found, as indicated in the column, with a stratum of yellowish marl between them and the blue, they are sometimes seen resting on that stratum, in a line whose undulating and broken contour plainly indicates the violence that accompanied their formation and conveyance to the spots in which they are accumulated. In fact, these fragmentary beds can only be regarded as the worn and broken remnants of the lighter coloured marls overlying the blue, sometimes usurping the place of the original strata which have been washed away to furnish the materials of which they are composed, and sometimes occupying the place of the uppermost of these strata, and resting on a layer which had escaped the destroying actions experienced by those above.

As might be inferred from its being of later formation than either of the other beds, and therefore higher in position in the series, as exhibited in the column, this marl is the first that shows itself as we ascend the James river. Spread out extensively in Elizabeth City county on the opposite side of the river, its most easterly exposure on the south side is at the mouth of Bennett's creek, a tributary of Nansemond river. Here it is seen nearly on a level with the water, but ascending this river, and therefore going slightly west, its southeastward dip causes it to rise to a greater and greater height, until the yellow marl appears beneath it, and as it still continues to rise, the blue comes into view beneath the yellow. From this, the line of its first exposure, it spreads out towards the west and north, forming the upper stratum in most of the exposures near the James river between Nansemond river and Pagan creek, displaying itself on and near the surface in the vicinity of Smithfield, and terminating at Day's Point. As measured on and near the James river, therefore, its breadth would include the distance between the meridian's passing through Bennett's creek, and the last exposure of it at Day's Point, being about 9 miles. But as we trace it towards the south, we find it rapidly contracting, so that at Suffolk only a narrow band of it remains.

Throughout the middle and nearly all the western portions of the Tertiary plain, as already stated, the upper beds, though often containing fragments of shells, present no accumulations of fragmentary matter such as have been described. Nor is the broken condition of the fossils there met with unaccompanied by those evidences of long continued trituration in water, and of transportation by currents, evinced in the worn and rounded forms and oblique deposition of the strata above described. They may therefore be reasonably referred to transient causes, while the others would seem to be more naturally explained by the tides and currents of the ancient coast line, formerly adverted to as adjoining the eastern margin of the higher plain.

Unlike the lower or blue marl, these yellow or light coloured marls are not found to be continuously or even very generally expanded beneath the Tertiary plain. Along the James river and for many miles towards the south, they are of very frequent occurrence; but as we

proceed still further south, they present themselves more rarely, and for the most part in places remarkable for their elevation above the general level of the country. So uniform is this connection of the beds in question with the more elevated ground about the middle of the tract, that few instances exist in which they are met with under other circumstances.

Thus beneath the high grounds formerly referred to as running from Nottoway swamp parallel to the Blackwater river, and along the river wherever the banks attain unusual height, the yellow marls are found rising in some cases to an elevation of 30 feet above the stream, while the blue stratum is seen skirting the base of the cliff in a narrow band, or is met with at various points beneath the highlands removed from the river. In the similar tract of elevated ground lying near and west of the Nottoway river, and extending from the neighbourhood of Three creek across Racoon and Hunting Quarter creeks, these yellow and light coloured marls are largely exposed, presenting a depth sometimes exceeding 20 feet, and resting on the blue stratum near the water level.

Though thus generally confined to the higher grounds, these yellow and light coloured marls are not continuously spread out even within these narrow areas, but appear to exist in irregular patches, lying nearly at the same level as to their under surface, though presenting great irregularity of thickness even in contiguous exposures, and often entirely wanting in one locality, while at some other place in the same neighbourhood they are met with largely developed.

This absence of the marls in question from so large a portion of the Tertiary plain, together with their occurrence in patches, and associated with the higher levels of the country, would seem to admit of a natural explanation in the powerful removing or denuding action of the water as it rapidly poured off from the surface in one broad tide at the time of the emergence of this plain from the bed of the sea. That a deep channelling of the surface, such as a retreating mass of waters might in most cases be expected to produce, is not now exhibited over the middle portions of this tract, would seem to have resulted from the uniform and gentle inclination of the plain towards the southeast, and from the filling up of the irregularities produced by the first rush of the waters by the sand and other sedimentary materials spread over the surface as the mass and energy of the water diminished. It is obvious that such an action as here supposed would give a fragmentary character to the upper stratum of the marl in general, and would accumulate the broken shells in heavy beds towards the eastern margin of the plain, conditions, both of which we have seen really to exist. The same agency too would account for the presence along that margin of the coarse gravel which has been described as overlying the fragmentary beds, while the constant wearing action of the waves along the beach would give a rounded figure to the fragments of shell, ere they had fairly become consolidated by the cementing process formerly described.

But whatever be the explanation of this discontinuous occurrence of the light coloured marls, the fact of their being placed at a nearly

[illegible] importance, for though we cannot re- [illegible] with them at any point [illegible] the height of [illegible] the blue stra- [illegible] are absent in their general [illegible] as in the depth [illegible] expected to be reached.

The line of [illegible] between the blue and upper marls, as indicated in the figure, is often undulating, and in some points presents such alternating and abrupt irregularities, as lead to the presumption that some important agitation of the waters intervened locally, if not generally, between the deposition of the two. At some localities chiefly near the eastern margin of the plain, fragments of the blue are met with in the yellow, and what is still more remarkable, fragments of the yellow in the underlying blue, as if soon after the commencement of the yellow marls, some violence had operated to intermix the two. At all events, it would seem obvious that during the deposition of the yellow and light coloured marls, a different condition of the waters must have prevailed, since the earthy matters mingled with the shells are so much more largely imbued with ferruginous matter, and contain comparatively little of the material of organic origin, which occasions the dark colour of the other.

In many portions of the tract, horizontal strata of sands and clays are seen overlying the beds of marl. When the surface of the marl is uniform, the lowest of these beds presents the appearance of having been quietly and slowly deposited upon it, but where indications of violence are met with at the top of the marl, the materials for some distance above are more or less obliquely stratified, and seem to have been poured in with some force. The upper of these earthy strata are usually arranged in level layers, and would seem to have been slowly [illegible] the entire absence [illegible] the occasional recurrence of decayed [illegible] been deposited [illegible] lower [illegible] and extensive. Perhaps [illegible] cases of [illegible] formation of [illegible]

[illegible]

after the completion of our formations, spread similar materials over nearly every part of the surface of the Atlantic states between the mountains and the ocean.

I have thus endeavoured to present the reader with a brief sketch of the limits and subdivisions of our Tertiary formation, as spread out in the region south of the James river, and referring as I have done at each important step to the physical causes which would appear to have been concerned in the production of the various strata, whether of marl or earth and gravel, I have been influenced by the hope that the picture I was drawing would in this way be rendered not only more interesting, but more intelligible and useful. May I not further hope, that from the broader views thus exhibited, individual curiosity will be awakened to a more attentive examination of the deposits of this region, and that thus some additional practical good may be secured.

CHAP. 5.

Illustrations of the Column exhibiting the order of the Strata.

As exemplifying the application of a portion of the column, I will now refer the reader to the series of strata exhibited at a few localities, requesting however that he will bear in mind that similar details have been collected at nearly every important exposure within the district, of which a full account will be given along with other interesting matters connected with this region in the final report.

1. South shore of the James river in the neighbourhood of Day's Point and Burwell's bay.

From the spot a little above the mouth of Pagan creek, where the marl is first seen to emerge from the level of the beach, nearly continuous exposures of both the blue and yellow beds are met with for several miles, the chief interruption taking place at a marshy part of the shore, a short distance from the first appearance of the marl. Along this tract the *blue stratum* presents great undulations in height, attaining in some cases a level of 20 feet above the base of the cliff, but at all times *overlaid by the light yellowish marl.* This latter is often *fragmentary*, and cemented at the top, above which are layers of clay, varying from a fine and tenacious to a sandy and loose texture. Particles of green sand are disseminated through the marls, as well as the overlying sandy clays.

2. In the vicinity of Smithfield on Pagan creek, as well as along its tributaries, Smithfield creek and Cypress creek, the light coloured and the fragmentary beds are largely exposed, the latter constituting the rocks on the lower shore of Smithfield creek, and being encountered in the wells of the village and its neighbourhood. Some distance up the two tributary creeks, as at Makefree on Smithfield, and Scott's mill on Cypress creek, the *blue marl* is met with *beneath the yellow.* Similar remarks will apply to Chuckatuck and Nansemond river, the *fragmentary marl* marl making its appearance at the lowest or *most easterly* localities, and as we ascend and bend westwards, the yellow

appearing beneath, and eventually the *blue* coming into view a little above the water line. These appearances are of course irregularly presented in consequence of original undulations of the strata, as well as the broken or trenched condition of the surface throughout this portion of the Tertiary plain. In the vicinity of Suffolk and towards the west, the yellow and blue marls are observed at numerous points in the same relative positions, and abounding in the Mactra Modicella in beautiful preservation. The fragmentary layer disappears a short distance towards the west of the village, and the overlying beds consist of fine sands and clays containing very few pebbles and horizontally stratified.

3. On the Blackwater from M'Clenna's bridge northwards both varieties of marl are very frequently met with in the river banks and the contiguous ravines, and though less frequently exposed along the upper portion of the stream, as it penetrates Prince George and divides Sussex from Surry county, are still disclosed wherever natural sections of sufficient depth exist.

Just below where Burk's swamp empties into Blackwater, a high hill, which is part of the ridge formerly spoken of, bounds the river on the Southampton side, presenting at some points an elevation but little short of 50 feet, of which more than thirty are made up of the two marls. Here, wherever the face of the bank is open to inspection, the underlying *blue stratum* is found rising a few feet above the river level. It contains a variety of shells, the little Mactra being the most abundant. *Above* are the beds of *yellow and brownish marls*, the lower being a bright yellow clay full of this Mactra, the upper a yellowish brown sandy clay, containing the Mactra largely mingled with other shells. The top of the marl is undulating, and covered with layers of sand and clay, generally of fine texture.

4. On the Nottoway, from a little below Monroe to the neighbourhood of Carey's bridge, the blue marl is exposed at various points, but rarely if ever accompanied by the yellow. As already mentioned, it is found still lower down the stream, to some distance beyond the state line, beneath the water level in the bed of the river. Above Three creek, where the river adjoins the high grounds formerly referred to, both varieties of marl are seen.

On the estate of colonel Blow, about 1½ mile below Peter's bridge, these hills bordering the river present an elevation of about 50 feet, of which 25 consist of the yellow and light coloured marls. The upper portion of the marl is *ferruginous* and tenacious, and rich in the little Mactra, containing also concretionary nodules marked with impressions of this shell, and occasionally including small crystals of selenite or gypsum. Beneath this the marl is of a *greenish grey colour*, derived evidently from the numerous grains of green sand dispersed through the mass. These, with a rather coarse white or yellowish sand, constitute the chief material in which the shells are enclosed. A great variety of species is here presented, shewing a more perfect state of preservation as we approach the level of the *blue marl*, which at low water is visible along the margin of the stream. *The beds* capping the marl are fine pipe clays and sands.

5. On the Meherrin, a little inland, about one mile south of the state line near Flat swamp, both varieties of marl, abounding in the Mactra, are met with on the estate of Mr. Wood, but along the river higher up, the blue marl is almost the only one exposed until we pass Dupre's bridge. About 3 miles above this point, on the estate of Mr. Ivy, the river presents a section of about 20 feet, the upper five or six of which consists of light indurated sandy clay, below this a compact white sand, from 4 to 5 feet thick, containing near the bottom numerous impressions of shells—below this a very hard ferruginous layer, 2 to 3 feet thick, filled with similar impressions—and beneath this a *yellow* sandy clay abounding in the little Mactra and a small turrited shell, both in a very soft condition. Lowest of all is a *bluish* mixture of sand and clay including a great variety of shells. This continues to the water's edge and forms the bed of the river.

The localities above enumerated and briefly described have been selected remote from each other, and lying upon the principal streams, with the view of illustrating the statements formerly made as regards the continuity of the blue marl, as well as of shewing the true order in which the various beds are arranged, wherever the localities are of sufficient elevation to present a section of the whole of the Miocene strata. The reader will at once perceive the unvarying order of their position as above described, and its correspondence with that represented in the column, and is desired to bear in mind that no violation of that order has yet been observed in any of the numerous localities that have been minutely examined. He should also remember, that while the blue marl, expanding in thickness as it spreads west and north, becomes gradually mingled with the grey overlying marls, the distinctly yellow marl is rarely seen, having, as formerly indicated, been probably swept away, excepting in those higher positions where it is now almost exclusively to be found.

CHAP. 6.

Of the causes of the peculiar Colours of the Blue and Yellow Marls.

As will readily occur to the reader, the yellow marls owe their hue to an intermixture of oxide of iron, which even in the small proportion in which it is mingled with the other matters of these beds, is capable of imparting a bright ochreous yellow, or a deep brownish tinge. The source of this ferruginous matter so generally present in the upper marl beds, as well as in the clays and sands which rest immediately upon them in numerous places, is for the most part to be sought for in a peculiar condition of the waters at the time in which these beds were forming, and not in the penetration of ferruginous matter from the overlying diluvium. Such a condition would naturally result from the extensive prevalence of a turbid state of the sea, like that so often witnessed in the waters of the James river, when heavy rains have conveyed into them the red earthy matter met with so extensively on the surface of that portion of the state lying between the head of tide and the Blue Ridge.

It is true that some of the strata lying near the surface, would seem to have derived their brownish ferruginous stain from the infiltration of water charged with a particular compound of iron from above. But in such cases it will be remarked, that the shells have been either in part or totally removed, leaving in the stratum, once rich in calcareous matter, little more than the mere prints or impressions of the fossils; and this condition, not unfrequently observed in the Tertiary district of which I am treating, is as often remarked of the blue as the light coloured marls, being in a great measure dependent upon the proximity of the bed of fossils to the overlying acid and astringent clays and sands. But the bright yellow and ferruginous marls now referred to as forming the higher beds in the series, retain their fossils in as perfect a condition as the blue marls beneath them, and have evidently not been subjected to the dissolving action of infiltering copperas (sulphate of iron), but have received the ferruginous colouring matter, in the state of a sediment, from the waters in which the strata were forming.

The blue marls differ from the former chiefly in containing little or no iron, and in being impregnated to a greater extent with matter of organic, probably animal origin. Both varieties exhale by heating, a perceptible amount of carbonate of ammonia—and the blue becomes of a dark, nearly black, tinge, from the quantity of carbonaceous matter (charcoal) which is developed by the imperfect combustion. The same change though in a much less striking degree takes place also in the yellow. This greater prevalence of what appears for the most part to consist of animal matter, seems to be naturally explained by the deeper position of those strata—since in virtue of such a position they would receive by infiltration from the upper beds a portion of the animal matter derived from the decaying shellfish of those beds, which would be added to that originating from like decompositions in the blue marl itself—while the yellow marls thus robbed of a portion of this ingredient, would be without the means of replacing it from above.

Whatever be the cause of the difference in question, it is far from improbable, that if the fact of its existence prove as general as I have reason to believe it is, a sufficient explanation will be thereby furnished of the superior efficacy of the blue marls as manures, of which a very general impression is prevalent throughout the southern portion of this tract. It is true the amount of organic matter present in any of them is very small, but it should be borne in mind that in the application of stable manures to fields, the quantity per cent. added to the soil is very inconsiderable. Moreover the carbonate of ammonia, one of the exhalations from the manure heap, is an agent of considerable power, and this, though in very minute quantity, is certainly present in the marls in question, and capable of being removed by water as well as given off at a gentle heat.

CHAP. 7.

Amount of Carbonate of Lime in the Marls.

In looking over the following table of the per centage of carbonate of lime contained in the various specimens of marl enumerated, it will be seen that while great differences prevail among them as to the amount of this ingredient, in no instance is its quantity so small as to furnish a reason for omitting to apply the marl, on the plea of its probable inefficacy, as a manure. In comparing the value of these materials, as regards their more immediate effects, all who have had experience in their application to agriculture, are aware that the poorer marls are often productive of as much or even greater benefit than the rich, when through the softer texture of the shelly matter they contain, they are more easily spread with uniformity upon the land.

The rocky marls, some of which are as rich in carbonate of lime as ordinary limestone, are nevertheless but little likely to produce a striking improvement when first applied, though as they are slowly resolved into smaller fragments, they will scarcely fail to give rise to a permanent and increasing amelioration of the soil. Fortunately for a large portion of this district, the blue marl, which from its more general distribution, will be chiefly looked to as a means of agricultural improvement, besides containing in most localities a very adequate amount of calcareous matter, and having perhaps other advantages already glanced at, includes comparatively few shells of large size, and of a texture to resist for any considerable time, the action of the atmosphere and rain and frost. The little Mactra so often mentioned before as largely predominant in the upper and more accessible beds of this marl, readily falling to pieces and mingling in fine fragments with the soil, seems particularly adapted for prompt and efficient operation on the land. So also the Chama, a small rugged shell, conspicuous in the greyish and greenish marls, towards the middle and western portions of the tract, especially in the neighbourhood of the James river, though more resisting than the Mactra, is already sufficiently small to admit of an even distribution on the surface, and cannot long withstand the decomposing agencies to which it is exposed.

In reference to the subjoined table, it is scarcely necessary to add, that as well as could be judged, the specimens selected for analysis in these and previous instances, have been taken as presenting the average character of the bed, wherever extensively exposed. Including the sixty Miocene marls reported on at a former time, the whole number of these marls from the south side of the James river, which have been thus far analysed, amounts to no less than one hundred and ten, and the entire number thus examined, since the commencement of the survey, some of them not yet reported on to the public, is upwards of 250. While indulging no exaggerated ideas of the importance of these numerous results, but regarding them as occasionally furnishing a guide in the application of our marls, I may be indulged in saying what I am confident would be found true, that so large a body of che-

[illegible] time, been presented to [illegible] the close. And in conclusion, [illegible] series of such analyses [illegible] localities in other parts of [illegible] some remaining points in the district [illegible]. Towards this object, as it is impossible, either in person or through my assistants, to visit *every marl* bed in the state, I would ask such persons as are interested in these results, to procure specimens of their marls, which if not obtained in the course of further explorations, will reach me by being transmitted to Richmond, to the care of the Board of public works.

SECTION III.

SOUTHERN DISTRICT EAST OF THE BLUE RIDGE.

CHAP. I.

[illegible] General Geology.

The exploration [illegible] have been carried on by making [illegible] sections, traversing the [illegible] range of the [illegible] between the [illegible]

Of the large mass of information thus collected, a brief outline will be now presented, embracing such details and general results as may serve to illustrate the progress of our operations in the district under consideration, and as an accompaniment to this sketch likely to be useful to such as are unacquainted with the terms by which the numerous varieties of rocks and minerals met with in this region are properly to be designated, I will in the first place introduce a description as familiar as possible of the more important of these varieties, according to the names by which in scientific language they are respectively known. In entering on this description, it may not be inappropriate to observe, as bearing upon a common misconcepton as to the utility of these learned technicalities, as they are sometimes called, that of the necessity of some such special designation for each peculiar mineral, mixture or compound, no doubt can be entertained when it is considered that in the common language applied to these objects, materials of very opposite character and composition are confounded; as, for example, granite and gneiss with sandstone, mica slate with soapstone, and ores of iron with those of silver, lead or gold, and that in different districts, the same material is often called by different names; and when it is further borne in mind, that in a multitude of cases minerals and rocks have received no common name, although from their peculiarities of composition and use, they are entitled to some specific appellation. In a word, the technicalities of science in these particulars are equally necessary with those of the workshop, the warehouse, the plantation or the mine, because they equally refer to the *peculiarities* of objects, to each of which, as matter of convenience, it becomes necessary to appropriate a particular name, distinguishing it from the others.

The greater portion of the district in question is occupied by rocks of a very ancient geological date, for the most part appertaining to the class called primary—some of these occurring in irregular masses or prolonged beds, consisting of materials having a crystalline structure, are destitute of any regular stratification, and incapable of being subdivided into uniform layers. These, from their analogy to undoubted igneous products of ancient as well as modern formation, geologists would with one consent refer to an origin depending on the agency of subterranean heat. Others also presenting the crystalline stucture, though with far less of distinctness, are regularly stratified, and more or less divisible into thin layers or sheets, while others again with much less, and often with but little, of this structure in their parts, exhibit the stratified arrangement and the slaty lamination in a very remarkable degree. To both of these varieties, which in the language of some geologists may be denominated *metamorphic rocks*, would be ascribed an origin due in the first place to the deposition from water of the materials composing these rocks in the stratified form they now present, and in the second to the modifying agencies of heat and other causes, imparting more or less of a crystalline character to the materials thus brought together, and in a greater or less degree obliterating the original structure of the mass. Thus, while the rocks of the first of these varieties bear no evidence either

in their composition or structure of any agency but that of heat being concerned in impressing the characters they now display, those of the two latter give intrinsic indications that aqueous and igneous causes in succession bore each a part in the formation of the strata as they now appear.

Besides the classes of rocks just mentioned, in which are included a great variety of mineral compounds, there occur in this region two others, one a rock of exclusively *igneous production*, and remarkable for being frequently found in lines or ridges more or less transverse to the adjacent strata, and from this as well as other reasons, judged to have been intruded among them in a molten state after their consolidation, filling the fissures created by the subterranean movements accompanying the intrusion, the other consisting of materials collected in *the form of sediment* by the *action of water*, and excepting in a few instances where invaded by the before mentioned igneous rock, exempt from the usual indications of the modifying effects of subterranean heat. The former are the trap rocks of this region, the latter the group of sandstones, shales, &c. hereafter to be described under the title of middle secondary rocks. These last are the only mineral masses in the region, in which animal and vegetable impressions are to be found, and as hereafter will be seen, are composed in part at least of the fragments, and, as it were, sweepings of the unstratified and metamorphic rocks above referred to. Hence obviously they are of later date than these, but at the same time lay claim to a higher antiquity than that of the trap rocks by which in many places they have been penetrated from beneath.

CHAP. 2.

Mineral characters and contents of more important Rocks.

The following description of the mineral characters and contents of the more important rocks, whether purely igneous, metamorphic or sedimentary, found in this and other corresponding parts of the state, will, it is hoped, be useful in preparing the reader, not yet acquainted with the names and characters of these rocks, for understanding clearly the full development of the investigations in this extensive portion of our territory, to be published at a futute day, and taken in connection with the accompanying sketches of the several tracts more particularly occupied by each variety of rock, may serve to convey some practical knowledge of the geology of the district now more especially in view.

1. Quartz. A simple or unmixed mineral composed of pure silex, or the earth of flints. Clear white sand, if sharp grit, is nearly pure quartz in a divided state. Chemically, it is called *silex* or *silica*, and a rock or earth in which it abounds is called *siliceous*. Quartz is often met with in nearly or quite transparent crystals, terminated when perfect by pointed pyramids of six sides. It is often called flint rock, and when crystallized, diamond rock, from its transparency and its power of cutting glass. In almost every portion of our primary re-

gion, as well as in other parts of the state, this mineral may be found either in crystals or in beds or veins, in which latter forms it is less pure and transparent. It is chiefly in these veins or beds that the gold ore of this region has been found. The rock in such case is called auriferous quartz. Common clay consists of this comminated or subdivided quartz, blended with *alumina* or pure clay, of which pipe clay is an example, according as the one or the other predominates. The mixture is called *siliceous* or *argillaceous clay*, the latter term being formed from *argile*, synonymous with alumina. So also many *rocks* are termed *siliceous* or *argillaceous*, from their composition in this respect. Quartz or silex and alumina form the principal constituents of rocks taken in the aggregate, and of the two, silex is the more abundant. The same is true of soils in general, which in regard to their mineral nature, are but decomposed or pulverized rock.

2. Felspar. An unmixed mineral, very abundant in rocks. It is white, yellowish, flesh coloured, and of other hues, rarely transparent, and when so, called *glassy felspar*. Its crystals form the opaque white portion of common granite, which is often seen to decompose by exposure to the weather into a white smooth powder, resembling the finest chalk. This powder constitutes *porcelain clay*, and is found very abundantly in the neighbourhood of decomposing felspathic rocks. Numerous localities of this clay are met with in the primary region, among which may be mentioned a belt passing through Prince Edward and Cumberland counties, a little east of their courthouses.

As might be expected, wherever this mineral in decomposing state abounds, a tenacious clayey soil is the result. The principal ingredients of common Felspar are silex, alumina and potash—but there is a variety called *Albite*, from its peculiarly white colour, in which soda takes the place of the potash. This is the more liable of the two to decomposition. While undergoing this change, they lose their potash and soda, which are carried off by the pervading moisture. Owing to the presence of these alkalies, Felspar is capable of being fused into a kind of glass. Hence the impropriety of selecting for hearthstones for furnaces, as has been done in some instances in this state, granite or any other rock in which there is Felspar. The residuary clays from which the potash and soda have been removed, may be used in their crude state for the manufacture of *fire-brick*.

3. Mica. An unmixed mineral having a shining silvery surface, and capable of being split into very thin elastic leaves or scales. In common with some other minerals resembling it, it is vulgarly called Isinglass. It constitutes the shining part of granite, and when by the falling to pieces of the rock, caused by the decomposition of the Felspar, it mixes with the earth, its innumerable glistening scales are the mark of what is called an *isinglass soil*. It is of various aspects, transparent, green, black, silvery, golden. When perfect, the thin scales are regular six sided figures. It is one of the most indestructible of minerals, by ordinary natural agencies being found in the sa[illegible] the Tertiary formation, though to have reached such a positio[illegible] many instances have passed through the successive sta[illegible]

condary formation after its first separation from the primary rocks of which it was originally a part. The principal ingredients of Mica, are silex, alumina, potash and oxide of iron (or iron rust). In many rocks the scales of this mineral are arranged in layers, and thus impart to the mass the property of being readily split into slabs in the direction of these layers. Many superior varieties of building stone contain much Mica.

4. Talc. An unmixed mineral, bearing a strong resemblance to Mica, but distinguished from it by its want of elasticity when divided into thin layers, by its being readily scraped with the nail, and by the smooth and soapy feel of its surface—from which last property rocks containing much of it are not unfrequently called soap stone. Its most usual colours are various shades of green. In composition it greatly differs from Mica, consisting chiefly of silex and magnesia. This mineral is present in many of the rocks of our primary region, particularly such as have a slaty character. It is found in crystalline plates of a bright green colour, at the Folly in Amherst county, and in other localities.

5. Hornblende. An unmixed mineral of a dark green or black colour. Found in small slender crystals closely compacted together, or in crystals of a more granular form. It is the ingredient that gives the dark colour to many of the primary rocks, and to trap; and being much denser than either of the preceding minerals, imparts to these rocks their superior weight. When decomposed, it usually forms a soil of a deep red colour, always remarkably productive. The black sand so common in the neighbourhood of Hornblende rocks, is in part composed of the unchanged granules of this mineral. Hornblende is composed chiefly of silex, alumina, lime, magnesia and oxide of iron. To its lime, which sometimes amounts to 14 per cent., and in some measure also to its magnesia, may no doubt be ascribed the peculiar fertility of the soils it produces. From its weight and greenish colour, as well as from the occasional occurrence of a little copper with it, Hornblende is often mistaken for an ore of that metal.

6. Epidote. An unmixed mineral, sometimes crystallized in slender diverging crystals, sometimes in grains of various shades of green and yellow, but as found with us usually of a light green, harder, and a little more ponderous than Hornblende. Like that rock, when decomposed, it forms a soil of a deep red colour, and, if any thing, more fertile. The red lands of Albemarle, and parts of Nelson and Campbell counties are due to this rock and Hornblende, but chiefly to this. It contains the same ingredients as Hornblende, wanting the magnesia, and having more lime and alumina, the former sometimes amounting to 24 per cent. The red colour of the soil, derived from both these minerals, is due to the large proportion of oxide of iron they contain, sometimes amounting to 30 per cent.

This mineral forms the principal ingredient of the hard, light green rocks of the Blue Ridge, Southwest mountain and Green mountain, and of various minor ridges within a belt of about 20 miles east of the Blue Ridge, and is often found in those rocks in groups of delicate crystals. This also in some cases has been mistaken for copper ore.

7. CHLORITE. An unmixed mineral, of a leek green or blackish green colour, composed of minute scales of an earthy texture. It has the greasy feel of Talc, though in a much less degree, and may generally be distinguished from that mineral by not being separable into layers of such extent, and by its much more earthy appearance. Its ingredients are silex, alumina, magnesia, potash and oxide of iron—agreeing very nearly in composition, as it does strikingly in colour, with the substance found in New Jersey and in lower Virginia called green sand. There seems also reason to believe that it resembles the green sand in its fertilizing effects, for in the soil of the Green spring lands of Louisa county, and a similar belt in Buckingham, remarkable for the greenish aspect of the land, much Chlorite is disseminated.

This mineral is much less abundant than those previously mentioned, and occurs with us chiefly in a species of Gneiss, in the districts just named.

8. STEATITE, (a pure variety of soap stone.) An unmixed mineral, of various shades of grey, white, green, yellow, &c., of which grey and white are most usual, the colours generally arranged in spots or blotches, easily cut, somewhat greasy to the touch, not inclined to split in thin layers. It closely resembles Talc in appearance and properties, and, like that mineral, consists almost entirely of silex and magnesia. As is well known, soap stone is extensively applied in the arts, and for domestic uses, owing to the readiness with which it may be wrought into any required form, and its durability under an intense heat. As Talc and Steatite pass into one another by insensible gradations, much of the soap stone used is Talcose as well as Steatitic. This rock occurs in our primary region, at many points, in considerable extent, and of a quality to fit it for serviceable use.

9. SCHORL. An unmixed mineral, of a black colour and glassy surface. It is usually met with in the form of long crystals of about the thickness of a quill, maintaining the same thickness from end to end, and having from three to nine sides. When embedded in Quartz rock, as commonly found, its shining surface and its form render it very easy of recognition. It occurs at numerous points in Mecklenburg, Lunenburg, Amelia, Buckingham, &c., and is particularly abundant in the latter county in the neighbourhood of Willis's mountain. Its principal components are silex, alumina and oxide of iron. Specimens have been sent to me under the belief that it was anthracite coal.

10. KYANITE. An unmixed mineral, of various shades of blue blended with white, the blue and white often presented in veins on the same specimen. The figure of the crystal thin, broad and flat. It is hard enough to scratch glass. The crystals occur closely grouped together, and crossing or standing on each other. It is composed of silex and alumina, and is a heavy mineral, being more ponderous than Hornblende. Willis's mountain is a remarkable locality for this mineral, presenting it in great abundance, and of various hues.

11. SULPHATE OF BARYTA. A mineral usually of a white or yellowish white colour, sometimes crystallized, sometimes finely granular, in the former case slightly transparent, in the latter opaque. It

is readily distinguished by its great weight, being even heavier than most iron ores. In the compact granular form it is readily cut by the knife, from which property, as well as its colour, it has been mistaken for gypsum, and actually ground and applied to the soil. Its weight is nearly twice as great as that of gypsum, which would alone serve to prevent their being confounded. The chief use of this material is as a *white paint*, for which it is largely consumed, particularly in mixture with white lead.

Numerous small, and some abundant localities of the Sulphate of Baryta are known in the southern district, among which may be cited the ridge between Beaver and Opossum creeks near Lynchburg, and Bore Auger mountain in Bedford county. It also occurs in considerable quantities in Fauquier county.

12. GARNET. A mineral of a red, yellowish red, or brown colour, occurring in crystals varying in size from a pin's head to several inches in diameter. It is remarkable for the beautiful regularity of its form, and the number of its faces or surfaces, which varies from 12 to 24. By the uninformed a perfect crystal would certainly be pronounced the work of art. Its constituents are silex, alumina, lime and oxide of iron, the lime 20, the ox. iron 16 per cent. From the large quantity of lime present, it is a comparatively fusible mineral, and hence some rocks in which it abounds may be used as an auxiliary flux for iron ores, having the additional advantage of themselves furnishing a considerable amount of iron. It occurs in some of the primary and metamorphic rocks very abundantly, and is met with in the southern region, particularly in rocks of the latter class in numerous places. The neighbourhood of New Canton in Buckingham county, may be mentioned as an interesting locality.

13. GRANITE. An unstratified or igneous rock generally found inferior to or associated with the oldest stratified and metamorphic rocks, and sometimes penetrating them in the form of *veins*, and of *dykes* or *walls* rising in the midst of them. The common varieties of granite consist of quartz, felspar and mica, the first being the transparent, glassy ingredient, the second the white or pinkish matter disposed to crumble, the last the shining ingredient in plates or scales. All these materials are crystalline and entirely exempt from indications of the wearing action of water. When the granite is coarse, the constituent minerals are very readily distinguished from one another by the naked eye, but in the varieties of a fine texture the microscope is sometimes necessary. Rocks of the latter description are not unfrequently confounded with sandstone, and called by that name. In the latter, however, the grains of quartz are always more or less rounded or water worn, and when present the felspar is in a decomposed state, and the mica has lost its regular six-sided form. Talc and hornblende sometimes take the place of felspar and mica, and are sometimes present in addition to the other ingredients. A true unstratified granite, though extensively displayed in some parts of our southern district, is by no means of common occurrence. As an example of it, I would cite the belt of whitish, hard, solid rock, extending from a short distance east of Little Falling river in Campbell

county with a breadth of between one and two miles across the Staunton river in the neighbourhood of Brookneal.

14. SIENITE, is the name given to those varieties of granite in which the mica is nearly or entirely absent, or is replaced by hornblende, and in which the felspar is relatively abundant. It occurs in almost every variety and at numerous places throughout this region, embedded generally in the rock next to be mentioned. At Collin's ferry, Buffalo cr. and Whipping creek in Halifax and Campbell counties, a valuable variety is found composed of light or flesh coloured felspar, black hornblende and some quartz, but no mica. It is hard, permanent, with no disposition to decomposition, and occurs in large solid masses, seen projecting above the river and extending for some distance both above and below the ferry. It is here quarried for millstones, formed of a single piece, and is called mill stone grit, a name properly belonging to a sandy rock containing water worn pebbles.

On the James river, four miles above Greenway, near Harris's branch, there occurs in the bank a little away from the canal a body of dark sienite or sienitic trap in large irregular or globular masses, which are quarried for locks and culverts in this vicinity. The rock is composed of dark green hornblende and white felspar, both distinctly crystallized, and forms an admirable building stone easily dressed. The tendency to a globular form which these masses exhibit is very distinct and remarkable. This belt of sienite is of considerable breadth, and extends both ways in the general direction of the river for many miles. Other localities need not at present be specified.

15. GNEISS. A stratified rock composed of the same materials as granite, having a laminated texture. Usually, it has a much larger proportion of mica and less felspar than granite. It admits of numerous varieties in which hornblende, garnet, kyanite, &c. are more or less abundant. The rocks of this description are among the most common occurring in the southern district, and the continuation of the same region across the state. Owing to their stratified structure, many of these varieties admit of being quarried out in large and uniform slabs, the faces of which in many cases are thickly spangled with scales of mica. Gneiss rocks are in extensive use as building materials in nearly all the Atlantic states. In the southern district, they have been quarried below Columbia, and between that point and Lynchburg, and at various other places, both for public and private constructions.

The quarry immediately east of Columbia is situated in a hill from which a large amount of rock has been removed, principally for the construction of the aqueduct across the Rivanna river. The rock is here a grey granitic gneiss composed of thick beds, rolling from a nearly horizontal position to various directions of dip, the predominant of which as seen in the quarry is NW. The hill, viewed as a whole, presents an instance of globular concentric construction on a large scale, the layers of rock from 2 to 6 feet in thickness, appearing to be arranged in the form of successive shells, one upon another. This, which is a common feature in granite, as well as trap rocks, and seems referrable to the effects of heat, does not mark the true

stratification of the rock, which in the present instance, though almost obliterated, would seem to have originally been in planes dipping to the SE. This in general is the direction in which the plates of mica lie in the rock, from which results the further peculiarity, that when we stand upon the undisturbed beds at the quarry, the edges of these plates only being exposed, the rock presents a light grey colour, but when we view a surface exposed by the transverse fracture, it presents innumerable black shining scales of mica.

A similar rock occurs extensively on the opposite side of the river in Cumberland county, where it has been largely explored in three quarries. In fact, all these quarries may be regarded as marking the general position of a wide but variable belt of grey granitic gneiss extending for many miles both to the north and south of the James river.

Without attempting at this time to enumerate localities, or to enter into details in regard to this rock as examined at a great number of places, I will briefly allude to a few of the belts or bands of it which have been traced.

The rocks in the neighbourhood of Halifax C. H., and in a belt of country extending thence through Charlotte C. H. into Prince Edward county, are for the most part of this description. They contain much felspar, and are in general decomposed to some depth, forming a stiff clayey and sometimes gravelly soil, which is not productive, bands of hornblendic sienite occurring in various parts of it, as, for example, about Charlotte C. H., impart as usual a red tinge and more fertile character to the land. A short distance from Halifax C. H. on the road to Danville, this rock is boldly exposed immediately at the road. It is a dark grey gneiss, containing much felspar, and presents a striking instance of the penetration of such rocks by veins of igneous material. The two larger of these veins, consisting of felspathic granite, may be traced for many yards, and are seen crossing each other without any disturbance at the points of intersection, the smaller composed almost entirely of felspar in traversing the former, have occasioned a displacement of their opposite or corresponding parts, so as to shift the vein about two inches aside from its former direction, indicating by this the occurrence of two successive intrusions of the igneous matter, the latter attended with the production of fissures crossing and displacing the veins previously introduced.

Near Danville another belt of gneiss of similar composition is seen crossing the river above the bridge, forming the great falls, and extending northwestwardly, or in the direction of its breadth about a mile. This belt continues through Pittsylvania and Campbell counties.

A wide belt of micaceous and felspathic gneiss traverses Albemarle, Nelson, Amherst, Bedford, Franklin and Patrick counties, presenting frequent beds of granite and sienite, the latter more largely developed in proceeding towards the southwest. This zone, including the county seats of all these counties, extends on either side over an area of variable breadth, but sometimes reaching nearly to the Blue Ridge.

In all these belts of gneiss, much variation is observed in the materials of the rock as exhibited at different places. Hornblende, talc, chlorite, kyanite, and other minerals occurring incorporated in the mass. Where the first is present in marked proportion, forming a hornblendic gneiss, the soil, as might be expected, is of a red colour, as may be seen in the vicinity of Nelson and Amherst courthouses. The chlorite, as already noticed, gives a greenish tinge.

It should here be remarked, that in many varieties of gneiss displayed throughout this region, a very marked amount of sulphuret of iron (iron pyrites) exists in the form of brilliant crystals disseminated through the mass. This, as a general rule, impairs the durability of the rock when used as a building material, because of the readiness with which these crystals are decomposed by the atmosphere, and the softened condition of the mass they thus induce. Such rocks, however fresh and clear their surface when first removed from the quarry, in process of time become studded with small brown ferruginous specks, which gradually extend themselves so as to injure the appearance as well as the solidity of the mass. As would be anticipated, the soil produced by the decomposition of gneiss of this description possesses more or less of a reddish hue, but cannot be expected to display the agricultural character of that of similar complexion formed of hornblende, epidote, or other rocks abounding in lime. Hence, as is well known, there are tracts of red land noted for sterility, as there are others for their productiveness.

An interesting variety of gneiss is met with in Buckingham county, forming the chief mass of Willis's mountain and Wood's, improperly named on the map Appomattox mountain. When freshly broken, it is a whitish gneiss, composed in large part of quartz in grains, with a little mica, bearing some resemblance to a coarse sandstone, and containing a large amount of kyanite. The former mountain consists of two knobs with a low gap between. The beds of kyanitic gneiss are amply exposed on the top of both knobs in massive ledges, and in the steep precipices looking towards the west, the dip of the strata being to the SE. at an angle of about 75 degrees. Associated with these rocks are found schorl and magnetic oxide of iron. From the peculiar character of this gneiss, and the abundance and variety of the kyanite and other minerals in and around it, this mountain is destined to become noted among mineralogists. The following are some of the specimens collected at this locality:

1. Grey gneiss containing white kyanite, tinged red by iron.
2. White quartzose gneiss containing kyanite.
3. Finely crystallized kyanite, occurring in groups forming large masses—white, bluish and yellowish grey, and brightly streaked with blue.
4. Schorl in large groups of crystals.
5. Actinolite, a bright green mineral in long slender crystals, found in a micaceous gneiss.

16. Mica Slate. By an increase in the proportion of mica, compared with the other ingredients, the preceding rock passes into one possessing the slaty structure in a much higher degree, and which is

called mica slate. In this the plates of mica sometimes compose nearly the whole of the mass, being merely cemented together in parallel planes by a small amount of intervening quartz. In other cases the mica is less predominant, and some felspar as well as a large proportion of quartz are present, so as to furnish a mixture closely approaching to gneiss. In fact the passage from the one group to the other is by insensible gradations, so that by different observers the same rock is sometimes associated with them both.

As will readily be inferred, there is great variety in the composition and structure of mica slate. As seen in our southern district, it sometimes presents the mica in conspicuous scales, but more frequently in minute ones, abundantly disseminated in the mass, and giving to the freshly exposed surface of the slate a glistening surface and a certain degree of smoothness to the touch.

The principal belt of this rock extends through Buckingham, Campbell and Pittsylvania, into Henry county, becoming less fully developed as it proceeds towards the southwest. In general direction it conforms to the course of the James river between Scottsville and Lynchburg, passing across the river and expanding for some breadth into Nelson and Amherst counties, though not without the intervention of wide bands of sienite, gneiss, limestone, and another variety of slate presently to be described, in which the mica is either in part or wholly replaced by talc. As presented in Buckingham and Campbell over a breadth of about 8 miles, its predominant variety is a fine grained rock, in which the scales of mica are very small, and blended more or less with talc. Most usually it has the structure of a highly fissile slate, weathering into small flakes or chips, but in many places it is largely intersected by veins of quartz and epidote, and then exhibits great hardness and a more imperfect slaty structure.

For the most part the soils of this belt, varying from a light grey and greenish yellow to a mottled red colour, are comparatively unproductive, but whenever the latter tint, usually produced by the decomposition of the iron pyrites common in the rock, is accompanied with fragments of Epidote or Hornblende, indicating the source of the red colour, at least in part, better agricultural properties are displayed.

It will presently be seen that limestone is of frequent occurrence near the western margin of these rocks, but within the general belt of which I am now speaking, no where could it have been placed more opportunely for the agricultural improvement of this district. For, perhaps, of all the soils throughout the southern region, none have naturally less calcareous matter than those derived from the light coloured slates referred to—and if we are to be guided by the experience of those enterprising farmers living within this belt, who have availed themselves of this resource, none are more certain to derive amelioration from a judicious use of lime.

17. Talc Slate. As already indicated, the micaceous slates of the belt above referred to, are often found to contain a portion of Talc along with the Mica, and such is the resemblance of the two minerals thus finely divided, that it is frequently impossible to pronounce upon

the relative proportion in which they are severally present. When, however, the rock has the remarkably greasy feel and silken lustre of Talc, and exhibits few or no scales of Mica, it is called Talc slate—and where a marked, though perhaps not predominating proportion of Talc is present, it is more properly termed a Talcose slate.

These slates are chiefly met with in the range of micaceous slates above described—sometimes occupying a very considerable width, and presenting the Talcose material in large proportion—sometimes contracted to narrow bands and consisting of an almost pure Talc slate, and sometimes passing, as they are prolonged by insensible changes, into a less Talcose and more micaceous rock, until they terminate in genuine Mica slates.

18. Argillaceous Slate. The aluminous and siliceous materials always more or less blended with the Mica and Talc in the slates above described, in many instances predominate so largely as to form nearly the only ingredients of the rock. In such a case, when the silex and alumina, in a finely divided state, are mingled throughout the mass, forming a slaty rock, in which little or no indications of crystalline texture are discernable, the slate thus formed is termed a clay slate, or Argillaceous slate. Rocks of this description most frequently present a dark colour, and are reduced by weathering into thin and tender fragments, which quickly resolve themselves into a tenacious clay. They present, however, great variety in colour, texture and hardness, owing both to original differences in the proportion of the ingredients they contain, and differences in the degree to which igneous agency has modified them as to texture and composition. As a class, the Argillaceous slates are to be looked upon as exhibiting less of this modifying influence than either of the metamorphic rocks above described. As might be expected from the varying character of the slaty rocks embraced in the belt of which I have been speaking, we meet with instances of gradual change from the condition of Micaceous and Talcose to Argillaceous slates, and rarely find the latter entirely devoid of Mica or Talc. In the neighbourhood of Scottsville, both above and below, are seen various mixed slates, presenting by turns the argillaceous, micaceous and talcose characters, but especially the two former. At numerous points along the eastern flank of the Green mountain, and in the western part of Buckingham county, as well as in Campbell, the argillaceous character is well marked. The admirable roofing slate quarried in the former of those counties, lies in another and more eastern belt of slate rocks, much less extensively prolonged than the main tract of which I have been speaking. Here, however, the compact Argillaceous slate of the quarry forms but one of the varieties of a group found in the same range, comprising Micaceous and Talcose slates. This slate, remarkable for its toughness and susceptibility of cleavage in broad thin sheets, bears evident marks of the indurating and other modifying effects of heat. It not unfrequently presents crystalline flakes and veins of Chlorite, spots of Epidote and small crystals of a peculiar mineral, Staurotide, which is met with at several other points in the Micaceous and Talcose slates.

19. Quartz Slate, *or Quartzite.* Among the various modifications of the slaty rocks now under consideration, deriving their distinctive titles from the ingredient largely predominating in each, as might naturally be expected, there is one in which the silica or quartz remains almost alone. This still presenting the stratified arrangement, and to some extent, the slaty cleavage of the other rocks with which it is associated in position, and as it would also appear in origin, is not to be confounded with the clearly igneous quartz frequently found traversing in ramifying and intersecting veins, the gneiss and micaceous and other slates. It should rather be regarded as one of a series of products arising primarily from aqueous deposition, for a time accumulating little else than siliceous materials, upon which at a later period, the modifying effects of heat were powerfully impressed. This Quartz slate is sometimes distinctly granular, presenting the aspect of a pure siliceous sandstone, having the particles of sand partially fused together, sometimes it contains both Mica and Felspar in small amount—and by weathering, which removes the latter, becomes soft and porous. Not unfrequently it shows a fibrous structure, and the smoothed surface of a micaceous slate. In a word, it exhibits all the varieties of composition, and arrangement of parts, that might be inferred from the above view of its nature and origin.

This curious rock is displayed at various points along the James river, between Scottsville and Lynchburg, associated with Micaceous and Talcose slates and limestone, and in a similar connection in the general prolongation of the same belt as far as Leesville in Bedford county. A few remarks upon some of the localities in which it is seen, will serve to shew its character and general range.

1. On the eastern edge of New Market, Nelson county, are two ledges of this rock, the larger and eastern of which is a little westward of the bed of marble near that place. The smaller, about 150 yards to the west, is separated from the former by beds of Talcose slate. The principal ledge is a fine granular whitish and reddish quartz, the other fine and coarse granular.

2. At the mouth of Owen's cr. and again a little above Greenway, a similar rock occurs, presenting with some changes the usual southeasterly dip of the rocks of this district. It is distinctly stratified, some layers quite solid and 2 or 3 feet thick, others in a state of decomposition, not crumbling, however, but retaining their original shape, having become externally of a dark colour, and porous within, from the removal of the felspar, which along with mica exists in small quantity in the unchanged rock.

3. Lee's mt. about one mile west of Leesville, Bedford county, is composed of a fine granular quartz rock, occurring in large layers with a slaty structure, so that it easily rives out in masses or slabs of any required thickness and length. Its dip is generally to SE. at an angle varying from 60° to 80°. Some of the layers are quite hard, others softer and more easily dressed, and these are preferred by the workmen; others again still softer shew a fibrous structure like many of the talcose and mic. slates along the James river. The *very summit* of the ridge or hill is composed of the white rock in

nearly vertical layers, and having been quarried in many places, it appears from below like a wall of sandstone. Indeed, consisting as it does of pure siliceous grains without felspar or mica, its resemblance to compact rocks of that class is very striking. The prevailing rocks, both to the east and west of Lee's mt. are talcose and micaceous and argillaceous slates, and within half a mile in the latter direction occurs a bed of blue limestone, hereafter to be noticed.

Besides its beauty and durability as a building material, this rock would appear to possess such a power of resisting intense heat, as to fit it for employment in furnaces, in which application it is certainly deserving of trial.

20. Pseudo-Gneiss or Gneissoid Sandstone. The interesting class of rocks referred to under this title are remarkable for containing rounded grains of quartz, and in this and other particulars presenting the general aspect of coarse grits or sandstones, more or less altered after their deposition by the agency of intense heat. These quartzose grains are often larger than a pea, and in general of a milky vitreous aspect. The mass of the rock is made up of siliceous grains with more or less mica and with felspar, occasionally in distinct crystals, so that according to the proportion and mechanical condition of the ingredients, it approaches in appearance either to a sandstone or a gneiss.

During decomposition, these rocks plainly betray their sedimentary origin, as well by the rounded pebbles of quartz and sometimes felspar seen in relief on the weathered surfaces of the coarser varieties, as by the purely sandy soil into which they are ultimately resolved. In many particulars they present striking analogies to the lower beds of sandstone appertaining to No. 1, the lowest of the Appalachian series, where these beds are in immediate contact with igneous rocks on the western slope of the Blue Ridge.

The tract in which this interesting class of altered rocks chiefly occurs, lies near and within the western margin of the belt of micaceous and other slates before mentioned, and is bounded by well defined strata of these rocks on either side. Within this tract are two ranges of the rocks in question, of which that lying more towards the east is situated immediately on the west of the Green mountains in Albemarle, extending in a southwest direction so as to cross Rockfish river about 1½ mile above Morgan's ford, and in a northeasterly direction through and a little west of the town of Charlottesville. The other, separated from the former by a narrow band of talcose and steatitic rocks, pursues a parallel course, including nearly all of Findlay's mt., and as it proceeds northeastwards, Fall Hill mt., Applebury's mt., and what near Charlottesville is called the Ragged mountain, crossing the turnpike in a belt of more than half a mile in width. As might be expected, the character of the rock at different places within the ranges just described is liable to important variations, but in general features considerable constancy is observed, the rocks of the more eastern belt being for the most part of a finer grain and more gneiss-like character than in the other.

other rocks of the slaty belt in which these limestones lie, more particularly those of a talcose, micaceous and steatitic composition, whose range is near or adjoining to the limestones. It would seem, in fact, that in the original deposition of the various materials, including the calcareous matter, of which these numerous varieties of rock were formed, but little uniformity prevailed in the substances accumulated at different parts of the tract at any one time, so that while at one place the materials were such as afterwards to form a Mica or Talc slate or steatite, or a mixture of two or all of these, at another, calcareous matter was collecting blended more or less with the other substances just mentioned, giving rise to limestones more or less micaceous or talcose in their composition, and towards the extremity of the tract in which they were forming, gradually fading away from the increasing predominance of the other materials there undergoing a like accumulation. It is, however, not to be inferred that the calcareous formation has ceased to exist wherever it is not present at the surface. Indeed, observation has shewn that it may be so *enclosed* by the meeting of the adjacent strata at the top, that nothing short of a section of some depth would reveal its presence. In such a case, even though the general dip of the strata were very steep, it might shew itself at the foot of a hill or in a pit, though entirely absent on the top or at the surface. In such cases, which there is reason to think are not uncommon, these calcareous masses may be looked upon as large bodies of rock resembling in form, though not in nature or origin, enormous flat and tapering pebbles embedded to a greater or less depth in the adjacent rocks.

By conceiving numerous masses of this description, some of them of many miles in length and several hundred feet in thickness, thus enclosed in the strata of that portion of the slaty belt in which they are found, we can readily imagine that the extent to which they are exposed on the surface, will be dependant on the position in which they are cut through by that surface, and by the natural sections formed by the rivers and ravines. From these considerations, a ready explanation is deduced of the frequent absence of the limestone in a line prolonged from and in the direction of localities where it is well developed, and of its recurrence at intervals in that and parallel lines, or of what may be called the sporadic occurrence of the rock. In thus dwelling at some length upon the want of persistency, frequently so remarkable in the rocks in question, I am influenced as well by the wish to incite those interested in their discovery, and more particularly the farmers living near or within their range, to a diligent personal examination for them at every accessible point, as to render the geological conditions under which they occur familiarly understood.

The following brief details in regard to some of the more important exposures of these rocks, as they are seen successively in exploring the belt from the middle of Albemarle in a southwesterly direction, will serve to illustrate the more striking features of the formation, and convey useful information respecting the character of the rock at a number of valuable localities.

Commencing with the band of limestone exposed on Limestone run, immediately on the main road from Charlottesville to Richmond, we find the rock displayed over a breadth of about 100 yards, lying in a nearly horizontal position, but rolling a little towards the east. West of it is a bluish micaceous slate, on the opposite side a brown and rather argillaceous slate. The rock is a blue slaty limestone, with a little Mica and a few veins of white Spar. It is penetrated in a vertical direction by a vein of grey impure limestone, and covered where the upper stratum has not been removed, by a grey rock containing but little lime.

From this point it extends with but little interruption, though of variable breadth, in a NE. direction, following nearly the course of the Mechump creek, in the neighbourhood of which it is quarried at several places. Where the Louisa road intersects its range it has disappeared, but a similar band shews itself at the surface at captain Lindsey's on the south fork of South Anna river, and near Gordonsville. In a SW. direction it may be traced without interruption through Dr. Blættermann's plantation, where it has been extensively quarried for agricultural purposes, and applied to this use with signal benefit. It is here also a slaty blue limestone, containing some Mica and Talc, producing a lime which, though not white, forms a strong cement. The enclosing rocks are talcose and micaceous slates, which, as well as the limestone, are inclined at a considerable angle to the SE. Thence in the direction of Buck island creek, it shews itself at several points in the neighbourhood of the stream, and is quarried by Mr. Garland and others, but before reaching the road leading from Scottsville to Carter's bridge, it vanishes, the last exposure being in the neighbourhood of Mr. J. D. Moon's. It again appears about 1½ mile NW. of Dyer's mill at "Limestone Place," consisting of a single band of light blue slaty limestone about three feet thick, occurring in micaceous slate. It now crosses Ballinger's creek a little north of the margin of the red shale region, and in a short distance enters that tract, where, if it exist at all, it is deeply covered by the red rocks. At Ballinger's it is a light bluish grey slaty limestone containing a little Mica. A little west of the margin of the shales, it makes its appearance on Rockfish river near the mouth of Ivy creek, though in a belt lying westward of the former range, and still farther south a similar rock occurs at numerous points in the neighbourhood of Warminster on the James river.

The several parallel bands occurring in this vicinity, prolonged in the direction of their range or bearing, in other words towards the NE. would enter the confines of the red shales a little lower down the river, so that even should they be continued in that direction they are rendered inaccessible by the overlying rocks. These bands moreover are not to be regarded as the continuation of the ranges of limestone previously traced, but lie some distance eastward of them, as may be seen by referring to the map.

From the vicinity of Warminster to Walker's ford, frequent exposures are met with both on the river and its tributaries, including many varieties of the rock, some of which have the texture and cha-

racter of marble of good quality, and many are of sufficient purity to recommend them to use. Throughout this tract we perceive a multiplication of the number of beds and striking fluctuations in their thickness and composition at localities but little remote.

1. Referring to the more important of these exposures, we find the rock in beds of considerable magnitude, forming a cliff on the south side of the river at Travellers' Rest, the residence of major Yancey. The thickness of the limestone, as exposed at the quarry on the river side, is about 60 feet. The principal varieties occurring here are,

1st. Reddish close grained limestone.

2nd. Greyish compact granular.

3rd. Pink slaty micaceous.

4th. White slaty micaceous.

5th. Blue slaty micaceous, occurring a little lower down.

Much of the pink as well as the grey compact variety may be regarded as of good quality, containing, as will be seen hereafter, a large proportion of carbonate of lime. Portions of the former constitute a not inelegant marble, though too much intersected by veins to admit of being readily wrought.

2. About two miles below Warminster by the canal on the north side of the river, three ranges of limestone are disclosed. The most easterly is narrow, composed of a whitish compact rock. The middle range, about 40 feet in thickness, consists of blue slaty limestone with much calc. Spar. It is from this band that the iron works near New Canton are supplied with the rock used as a flux. About 150 yards above is a smaller range of granular and compact limestone, white and pinkish, occasionally slaty, with some calc. Spar and a little Mica. All these rocks are associated with talcose and micaceous slates, and like the slates have a steep dip to NW.

Higher up the river, ledges of the rock are seen on Swift island, and crossing Stevens's and Pigsborough creeks a short distance above their mouths, the latter locality lying considerably west of the range of those previously noticed. This brings us to the vicinity of New Market, where numerous interesting exposures are met with on both sides of the river, and to some distance westward: and like exposures are seen from point to point as we ascend the river as high up as Elk island creek. The following are some of the particulars relating to this portion of the tract:

3. About one mile below New Market and 100 yards north of the road leading to Warminster, there occurs a bed of compact limestone or marble, which is well exposed where cut through by Pounding Mill creek. It lies between talcose and micaceous slates, and presents at this point a width of between 60 and 70 feet. It is in general a white rock, though sometimes pink or flesh coloured, and occurs in irregular layers, which are nearly or quite vertical. In texture and colour it is well suited for ornamental work, but it is to be feared that from the number of veins and joints running through the rock, it is not sufficiently solid for quarrying as a marble. Of this, however, no adequate trial has yet been made. The same bed is again exposed on the west side of Tye river near its mouth, forming several

small ledges on the line of junction of the river bottom with the rising ground. It is just to the west of the direction of this bed that the curious ledge of quartz rock formerly noticed presents itself, and we shall see that a similar juxtaposition of calcareous and siliceous beds occurs at other points.

4. On the south side of James river nearly opposite New Market, the cliffs or rocky banks for about half a mile contain blue slaty limestone, generally quite micaceous. These beds appear to be continuous with those of a similar rock met with on the opposite side of the river above New Market along the canal.

5. Following the course of the river from New Market up, the blue slaty limestones just referred to are met with about one mile above the village. They form two thin beds, separated by a considerable interval occupied by mic. and talcose slates. The first is a blue rock, containing reddish calc. spar, width 10 feet—the second a blue slaty micaceous limestone.

6. Passing now a band of talc. and mic. slates, in the midst of which rises a narrow ledge of trap or greenstone, we come upon a bed of impure, white and pinkish compact limestone or marble, having a width of about 20 feet.

7. We are now carried successively over mic. slates and the bed of Sienite formerly referred to as affording so valuable a material for building, and at the mouth of Owen's creek strike upon another range of white Quartz rock, mentioned under a former head. Between Owen's creek and Greenway we have for 2 miles argillaceous slates, beyond these micaceous slates, and lastly bluish micaceous Gneiss, which is quarried at Greenway. Still farther on the micaceous slates and Gneiss continue for nearly two miles, excepting where interrupted by a heavy interposed bed of quartz rock. At the termination of this distance, we again come upon blue slaty limestone.

8. We now have a succession of cliffs on both sides of the river composed of bluish mic. slate and Gneiss, the beds of which cross the river about 3 miles above Greenway; after which, near Harris's branch, there occurs a body of dark Sienite, which has been quarried for locks and culverts, and of whose admirable qualities I have already spoken. One mile farther on, we meet with two ranges of blue limestone, having a granular structure, and containing some brown Mica and white calc. Spar. They are enclosed in mic. slate and are about 20 feet in width.

9. This brings us in a short distance to a broad belt of marble 40 feet in thickness, consisting of a white and grey compact rock divided into layers from 3 to 4 feet in thickness, and of uniform texture and great solidity throughout, dipping to SE. at an angle of 50°. This forms a cliff which is cut through by the canal. In texture, colour and solidity, this rock gives every indication of being well adapted to be wrought as a marble, and can hardly fail to become valuable for this or other purposes.

10. Beyond the marble we again pass over Mica slates, and within a quarter of a mile of Elk island creek, meet with a bed of blue limestone veined with calc. spar. This, as exposed, has a width of

from 40 to 50 feet—dips also to SE. Micaceous slates recur, and just at the mouth of Elk island creek, we find another but thinner bed of blue limestone, which is quarried.

11. At the distance of about half a mile above the mouth of Elk island creek, near the furnace of the Elk creek iron manufacturing company, a blue slaty limestone occurs in the vicinity of the ore bank nearest to the establishment, and a similar rock is met with in several narrow parallel belts for some distance westwards. Exposures also occur at some points within the triangular space lying between Buffalo ridge and the James river and Elk island creek, whose margin has now been traced. These beds however appear to have thinned out before reaching Christian's creek.

12. On the southern side of the river a belt of limestone is seen crossing Buck island creek about half a mile above its mouth, and another more westerly bed is exposed at Walker's ford nearly opposite the mouth of Christian's creek. This is blue and slaty, and associated with talcose and micaceous slates.

13. The calcareous beds having now thinned away on the northern side of the river, appear to undergo a correspondent expansion on the southern. On Stonewall creek, a short distance below Ross's furnace, and about 2 miles in a direct line from the river, a belt of limestone is exposed, measuring at this place upwards of three hundred feet in thickness. It is blue, sometimes sparry and white, sometimes granular, and inclining to be crystalline. This belt possesses great importance, not only on account of its extent, but its contiguity to the extensive beds of rich iron ore which are used at the furnace, the limestone lying a little east of the most eastern band of ore.

14. Continuing our observations up the river, we meet with a range of blue limestone, generally slaty and micaceous, about half a mile below the mouth of Archer's creek. The principal varieties occurring here are,

First—Greyish sub-crystalline limestone containing small rhombs of calc. spar.

Second—Dark blue slaty limestone, micaceous, containing small rhombs of dark calc. spar, and some iron pyrites.

Third—Blue slaty limestone, micaceous.

The thickness of the bed may be estimated at 70 feet.

15. About 2 miles above the mouth of the creek, near where the old Richmond road crosses, and therefore in a position more to the east than any of the beds hitherto noticed, we find exposures of a quite thick belt of blue limestone, both at the ford of the creek and some distance beyond. This rock, which is enclosed by micaceous slates, has a high dip SE. It is blue, micaceous, somewhat slaty, and contains some calc. spar.

16. The belt described as shewing itself a little below the mouth of Archer's creek (14) would appear to be prolonged, though seemingly not continuously on the surfaces, in a direction to intersect Opossum creek at the point of crossing of the Richmond turnpike near its mouth, and at that of the road to Campbell courthouse, at both of which places a bed of bluish micaceous limestone is exposed. The same is also

seen at various places in the line connecting these points, between Opossum and Beaver creeks. As seen near the crossing of the Richmond road, it shews itself in a bold cliff on the creek, in thick, solid layers dipping SE., having at the quarry a width of about 50 feet, and being bounded by mic. slates on both sides. It is deep blue, dull, micaceous, and with thin layers of Mica between the strata.

17. The belt described as crossing Archer's creek, some distance above its mouth on the old Richmond road, would also seem to be prolonged, though not continuously at the surface, making its appearance on Little Beaver creek, which it crosses, and shewing itself extensively along the western margin of Big Beaver as far up, nearly, as where the road to Campbell courthouse crosses the creek. At captain Stephen Perrow's this belt is about 100 yards wide, and consists of grey, bluish, and white limestone. The bluish or clouded generally contains Mica and iron pyrites, and grains of bluish Quartz; the white is fine grained, pure, and free from Mica, and in fact, is a marble of moderately good texture. The same rocks are seen about half a mile below on the land of Dr. Stevens adjoining the creek, and are here bounded on the west by a belt of micaceous slate in which occurs a bed or vein of fine granular Sulphate of Baryta of a pure white colour. On Chilton's plantation the limestone crosses Beaver creek, soon after which it strikes over to Little Beaver, but soon becomes concealed, so that it is not well exposed again until we approach Archer's creek. Between Chilton's and Little Beaver it is a coarse grained white and grey and bluish limestone.

18. West of the mouth of Opossum creek, about midway between it and Licking, several narrow bands of limestone shew themselves near the river, being the only representatives in this part of the tract of the belts of marble and limestone found in the neighbourhood of Elk Island creek, Greenway and still lower down. The strata as exposed from the mouth of Archer's creek to the western termination of the cliff in which these bands occur, present some points of interest, and may therefore be briefly alluded to in the order in which they occur.

Immediately above the mouth of the creek is an extensive exposure of light blue Mica slate, with embedded Mica in dark scales. The bearing or range of the strata is NNE., and the dip steep towards south and east. A large *vein* of Quartz is finely displayed in the face of the cliff, cutting through the strata at right angles, thus evincing its intrusion as an igneous material into the beds of Mica slate after their deposition, and furnishing a beautiful illustration of the relation of much of the Quartz rock of this and corresponding districts of the state, to the surrounding mineral masses. A large proportion of this Mica slate is well suited for building, being procurable in large uniform blocks capable of being dressed with ease.

Between Beaver and Opossum creeks are exposed beds of Quartz rock of very different character and origin. These present themselves in heavy strata, enclosed by Mica slates on both sides, and dipping in conformity with the slate, at an angle of 45° to SE. The whole thickness of the rock is about 200 feet, consisting chiefly of two bands of 100 feet each, separated by the slates. This rock is dense, fine

grained, containing a little Mica, and in some layers embedded grains of bluish Quartz, presenting the characters of an altered sandstone. It has been extensively wrought at Cabell's quarry for the works on Beaver creek.

At Opossum creek we have bluish micaceous slate, and in about half a mile a cliff begins which extends for about 2 miles along the canal. Here we have bluish and greenish mic. slates with veins of Quartz, grey micaceous slate, and then the most eastern of the bands of limestone, which is about 7 feet thick, blue, slaty and micaceous, with some spar. The position of this band is vertical, but it does not rise to the top of the adjoining slates, which fold over it so as present a thickness of about 10 feet between its termination and the surface, displaying in this particular, a feature in regard to these beds of limestone formerly adverted to, as probably characterizing them very generally.

About 50 yards above this is another ledge 5 feet wide, of light blue slaty limestone.

A little beyond the last, is a third bed consisting of white and grey rather granular limestone, looking like marble, but wanting solidity, being slaty and penetrated by seams. Thickness about 10 feet.

Adjoining the former is bluish Talc slate, west of which we meet with a fourth bed, consisting of a white slaty limestone in thin layers covered with a film of Talc. Thickness 20 feet.

Beyond this is dark green Talc slate with wrinkled surfaces, and then a curious bed of micaceous Gneiss, with a great deal of Quartz, about 20 feet in thickness, rising from the base of the cliff in a vertical line, then bending so as to become horizontal, and again by a similar rectangular turn rising vertically to the summit.

The narrow bands of limestone here described are not prolonged to any considerable distance towards the southwest, and no doubt thin out in that direction as well as towards the northeast.

19. Tracing, in a southwestern direction, from Beaver and Opossum creeks the tract of slates with which the calcareous beds have thus far been observed to be associated, we find numerous exposures of limestone in two ranges, one following the general course of Flat creek, the other that of Buffalo. The former or more eastern range may be seen near Horner's about 9 miles south of Lynchburg on the Pittsylvania turnpike. It occurs over a considerable space in the flat meadows at the head of the creek, and is here a blue limestone forming a tolerably white lime. Below this it may be traced from point to point as far as the Otter river near the mouth of the creek, shewing itself well at Mr. Ward's on a small creek above Quarry branch, and at Scott's mill, judge Saunders's, and major Smith's on Flat creek. The breadth of this belt, though far from uniform, is very considerable: the rock as seen at judge Saunders's is blue, slaty and micaceous, intersected by small veins of Quartz, and dips at about 40° to SE. Adjoining it are Talcose and Micaceous slates.

20. The range on Buffalo creek is separated from the former by an interval several miles in width, occupied by mic. slates with Epidotic and Hornblende rocks and Quartz containing beautifully crystallized *Schorl.*

The limestone is seen at several points on the creek. On Mr. Andrews's plantation it forms a narrow band in mic. slates and Gneiss, and is a white granular limestone with some Mica. At Mr. Ro. Irving's it forms the face of the cliff on the side of the creek, and has a width of about 80 feet, dipping to SE. It is of various textures, from a coarse granular to a slaty fine grained limestone of a grey colour, and forms a white lime.

21. The belts above described as ranging along Flat and Buffalo creeks, thin out in proceeding SW., so that the latter does not reach the Otter river, and the other disappears after passing through Dr. Hayden's plantation south of that stream. But lower down the river than the range of the Flat creek rock, there occurs at the mouth of Scott's creek, on the plantation of captain Tardy, a bed of limestone of sufficient extent to form a cliff near the Otter. It is a bluish granular rock, shewing itself in heavy beds.

22. On Sycamore creek near Clement's ford of Staunton river, a thin bed of white granular and slaty micaceous limestone is exposed, enclosed in macaceous slates, but this soon thins away, and no rock of this description has been met with in this direction further to the SW.

23. In the prolongation of the line of the Buffalo creek rock, however, though not continuous with it, a bed of limestone makes its appearance near Goose creek, between one and two miles above Leesville, situated at its mouth. It presents itself about half a mile west of Lee's mountain, of whose layers of beautiful Quartz rock mention was formerly made, and as exposed at Mr. Arthur's quarries, has a thickness of about 40 feet. It is blue and slaty, but not micaceous, contains some calc. spar, and burns into a white lime. Dips to SE. at an angle of 60°, and is in contact with greenish Mica slate. A similar rock occurs near the southern base of Smith's mountain, on the plantation of Prof. Tucker.

24. Following the general direction of the tract, we meet with one other bed of limestone, near the ford of Pig river, a little above the mouth of Glade creek in Franklin county. It is blue, slaty, occasionally micaceous, and with small layers of calc. spar. Width about 15 feet. It is quarried for the use of the furnace at Rocky Mount. Further to the southwest the Talcose and Micaceous rocks, always observed to be associated with the limestone, rapidly thin out, and no traces of them or the limestone are to be seen in crossing Patrick and Henry counties, from Martinsville to the furnace on Goblintown creek. Whether these rocks re-appear still nearer the state line has not yet been determined, though it is not improbable that such is the fact, as at no great distance south of the line they are met with in North Carolina.

The foregoing details, comprising the principal, though not all the localities of calcareous rock within the district of which I am treating, have been given at some length, with the view of inducing those who reside within or near the tract in which these rocks occur, to make diligent examination in their respective neighbourhoods, that any hitherto concealed beds, of which it is by no means improbable some

may yet be found, may be brought to light and turned to useful account. The minuteness of our researches as manifested in some of the above details, has been such that I am confident no belt of considerable thickness has been passed over—but even a band of this rock of only a few feet wide, may prove an important acquisition to the agriculture as well as the household economy of a neighbourhood, and would certainly well repay the trouble of exploration.

From that portion of the above details relating to the numerous exposures on and near the James river, particularly when connected with the chemical results in regard to the composition and peculiar qualities of those rocks which are to follow, it would seem scarcely to admit of doubt that the beds of limestone and marble met with in that portion of the tract, are destined hereafter to be of more than merely local value, and that they will not be suffered to remain so little wrought, when their highly favourable position gives them an advantage more than compensating the inferior excellence of the rock at many though by no means at all the exposures.

As a very useful aid to those who are interested in the above details, and who desire to trace the calcareous beds through intervening points not mentioned, as well to readers generally, anxious to follow understandingly the descriptions I have given, I would recommend a continual reference to the large state map while reading them, as I have endeavoured so to specify localities as that they may be fixed with sufficient precision on the map. For the sake of permanent future reference, it would also be found useful to make a distinct mark with a pen or brush at each locality thus determined; and I would take the liberty of recommending a similar procedure where boundary lines of formations are traced in the reports. Such visible demarcations, while greatly assisting the reader in forming clear conceptions of what is described, become parts of the geological picture of the region, whose purport is afterwards recognized at sight, and in the present case may serve a purpose of use as well as gratification, until the geological map of the state is in the hands of the public.

Composition and properties of the Limestones and Marbles above referred to.

Numerous specimens of these rocks, gathered from all the important localities visited during the last and preceding seasons, have been selected for chemical examination, and of a portion of them our analyses have already been completed. From the results, as stated below, it will be seen that in many instances they contain a large proportion of carbonate of magnesia, a fact which, taken in connection with their siliceous character, led me at once to infer their capability of furnishing a lime suited for the purposes of a water cement. I have accordingly instituted a series of experiments designed to test their properties in this respect, and though the investigation will require some further time to bring it to maturity, I am enabled to announce the fact, that the rock of some of these beds yields a hydraulic lime which, though it sets slowly, forms a solid cement. I may

further state what has been mentioned incidentally before, that the grey and reddish lime of many of the poorer beds, containing some magnesia as well as much siliceous matter, will be found to form a mortar for common purposes of greater hardness and durability than can be made by the use of the pure white lime, which is so generally preferred; and that though comparatively few of these beds will yield a perfectly white lime, it should be borne in mind that the light grey and cream coloured limes produced from some of the richer rocks, are little if at all inferior in strength to the white limes in common use. Of the falsity of the opinion so prevalent that a coloured lime must of necessity be of inferior strength, no clearer proof could be adduced than the well known fact, that the presence of less than one per cent. of oxide of iron in the lime is sufficient to give it a very decided reddish or brownish tinge.

23. Iron Ores. On this head only a few observations can be usefully presented at the present time, as the chemical examinations relating to these materials are as yet too little advanced to furnish a body of analytical results sufficient to illustrate their composition and probable economical value. The extensive beds of these ores found at some points in the southern region, their great richness in iron, and their proximity in several instances to some of the belts of limestone above described, together with the favourable position in which some of them are placed as regards water power and facilities of transportation, give them a not unimportant rank among the mineral resources of this portion of the state. These deposites are however by no means so numerous in this region, as from the deeply ferruginous tinge of the soil over extensive districts, and the frequent occurrence of loose fragments of ore upon the surface, ordinary observers have been led to imagine. All the slaty rocks of which I have treated above are more or less impregnated with iron, usually shewing itself in the undecomposed rock in the form of crystallized sulphuret of iron or iron pyrites, and in many instances bearing a large proportion to the other materials with which it is intermingled. Nor is it exclusively confined to the class of rocks in question, occurring sometimes in equally marked amount in beds of Gneiss and in veins of Quartz, particularly such as have been found to contain gold. This mineral may be known by its yellowish metallic lustre, and the generally cubical or square form of its crystals. Though worthless in itself, it would appear to have been the source whence some of the most valuable and extensive ore beds of this region have been supplied.

The beds referred to are those consisting of the brown and ochreous ores hereafter to be mentioned. A few remarks upon what would seem to be the theory of their formation will, I hope, not be deemed inappropriate as a part of the present brief sketch of the geology of our southern region.

The brown and ochreous iron ores contain the metal in the state of an oxide, and are made up of this oxide, together with silex, alumina and water. The oxide contains 70 per cent. of metallic iron, so that were the ore composed of this alone, each hundred pounds ought to yield seventy pounds of metal. In the richer ores as much as 85 per

cent. of the oxide is sometimes found, the remaining 15 per cent. consisting principally of water. This would correspond to about sixty pounds of iron to the hundred of ore, and is an amount scarcely ever obtained in the operations of the furnace.

The ores in question are uniformly found associated with Micaceous or Talcose slates or Gneiss, in which the sulphuret is or has been present in great quantity. In the immediate vicinity of the bed, these rocks are seen in a decomposing condition, and impregnated with ochreous matter, which is the material of the ore. In fact, with a little attention, the various gradations may be traced from the unchanged rock, at some distance from the bed, to the softened and decomposing material in which the sulphuret has disappeared and the dark brown stains of oxide are presented, and thence to a mixed substance consisting of the matter of the rock, with a predominance of the oxide, from which we pass into the massive and comparatively pure ore. Of the stages of chemical change by which this conversion would seem to have been brought about, the first is obviously the decomposition of the sulphuret of iron, and the production of copperas or the sulphate of iron, an effect continually witnessed where moisture and air have access to the sulphuret, and the second the separation of the brown oxide from the copperas, probably in some measure by the action of the magnesia and potash present in the Mica, Talc and Felspar of the adjacent rock. In this view of their production, the ores in question are to be regarded as of much later origin than the adjacent rocks, and indeed as being in some places in progress of formation now. Striking examples might be referred to of beds of Micaceous and Talcose slates, in which knots of such ore are to be met with disseminated through the mass, and still in part retaining the structure of the slate, so as to exemplify one of the stages of change before noticed, in which the production of the bed of ore has not yet been carried to its completion.

Besides the brown and ochreous ores, there occur also two other varieties, viz: the *Micaceous oxide* and the *Magnetic oxide*. The former is not unfrequently associated in small quantity with the ores first mentioned, but most commonly occurs in small veins included in Quartz. It is distinguished by its glistening scaly crystals, not unlike those of a dark brown Mica, but unlike these it yields a bright reddish brown powder when bruised, and will stain the fingers of this hue when rubbed. Though of common occurrence, it is not found in large quantities. The composition of this ore is the same as that of the pure brown oxide, but unlike that variety it is never united with water.

The Magnetic oxide, when pure, is richer in iron than either of the preceding, containing within a small fraction of 72½ per cent. of metallic iron. It is distinguished by its nearly black colour in mass as well as when reduced to powder, and its strong action on the magnetic needle, attracting one extremity and repelling the other. It is from ore of this description that nearly all the Swedish iron, so celebrated for its excellent qualities, and so well suited for conversion into steel, is extracted.

This variety of iron ore occurs at several points in the southern region in the form of beds or strata of considerable thickness and of good quality.

The following enumeration of some of the exposures of these ores may serve to indicate their geological position as well as their extent and general characters:

1. In Buckingham county an extensive bed of the brown and ochreous ore has been traced for many miles in a direction southwestwards of the furnace near New Canton. Of this deposit some account was given in my first report.

Omitting further details at this time, I would merely remark that from its continuity and thickness, and from the general richness of its contents, this bed deserves to be considered as of high economical value. The iron made from it is for many purposes regarded as of good quality, though like most of the metal manufactured from the ores east of the Blue Ridge, it requires the admixture of a softer material in converting it into bar iron. The position of this bed between Micaceous slates, and the graduation of the ore into slate along the sides of the bed, afford good illustrations of what has been said in regard to the origin of these ores.

2. In the same county a bed of the brown ore is extensively exposed on Stonewall creek in sight of Mr. Ross's new furnace, and shews itself at several other places in the neighbourhood. At the furnace it has a width varying from 10 to 15 feet—at Mr. Yeatman's, half a mile below, its width is 12 feet. Its position is nearly vertical, included in yellowish Talcose slate, and its range or bearing is N. 20° E. The ore is generally compact and dense, but sometimes cellular, and containing ochre. Higher up the hill and eastwards of the former, another parallel bed occurs, consisting chiefly of a yellow ochreous oxide of iron with numerous and large cavities. Still more towards the east we meet with the range of limestone formerly spoken of, furnishing a flux to be used with the ores.

3. Near the mouth of Elk Island creek in Amherst county, two or more considerable beds of ore are met with, the more eastern of which, about half a mile above the mouth of the creek and a quarter of a mile above the furnace, is from 4 to 8 feet in thickness where explored, and is a brown oxide of iron, sometimes micaceous, contained in Mic. and Talc. slates. Half a mile westward occurs another bed, consisting principally of slaty and micaceous ore, and at various points in the vicinity bog ore is abundantly met with, serving a useful purpose in union with the compact and micaceous ores. As already stated, beds of limestone are found within a short distance of the ores.

4. A little east of the belt of grey granite, formerly described as ranging through Campbell county near the Charlotte line, and crossing the Staunton river at Brookneal, there occurs a prolonged bed of ore, similar in character to those above described. About a mile NE. of col. Hancock's dwelling, the width of the bed is 8 feet, but there is reason to believe that at some points it swells out to more than double this amount. It here ranges in a NNE. direction, has a high eastern

dip, and is associated with Mica slates. The ore is a brown oxide, sometimes quite compact, sometimes ochreous, and occurs in large masses on the east side of Hot creek, (one of the branches of Falling river,) near its mouth, much ore is seen on the surface, and has been exposed by diggings—apparently the continuation of the bed explored on col. Hancock's land and its vicinity.

5. Near Rocky Mount in Franklin county, a little north of the bed of Steatite formerly described, the Magnetic oxide occurs in sufficient quantity to supply a furnace in the vicinity. The ore is granular, of a black and greenish black colour, and is associated with decomposing micaceous slates—width of the bed varying from 4 to 6 feet. Another bed of the same description, several feet in width, is met with a little north of the village. Impure bog ore occurs in the neighbouring meadows, yellow and ochreous, accompanied on the surface with the grains called shot ore. Seven miles west of the village we meet with the brown oxide in Mica slate.

6. In Patrick county, a little west of Goblintown creek and on the east side of Stewart's Knob, we find the magnetic oxide exposed at several places, the main deposit supplying the Union iron works in the vicinity, being a bed of from 3 to 6 feet wide, of a fine grained, generally black ore, sometimes having a greenish tinge from the intermixed scales of Talc, and sometimes red and ochreous.

7. In Buckingham county, about a mile east of Whispering creek and nearly in a line with Willis's mountain, a heavy bed of the magnetic oxide crosses the road leading from Maysville to Ca Ira, and may be traced for some distance in a NE. and SW. direction. It is from 6 to 8 feet in width, solid and dense, generally bright and specular, though sometimes dull. It affects the needle powerfully, and is evidently a very rich ore.

Further details in regard to these, and a similar full account of other localities, are reserved for a future time, when the chemical examinations connected with the subject, shall have been brought to maturity. But it will be seen from the particulars which have now been stated, that the portions of the southern region referred to are by no means wanting in supplies of this mineral, and that some of the most extensive beds are very favourably situated, both as regards the limestone so essential in the manufacture of iron and an easy conveyance of the products of the furnace to market.

Rocks exposed in a Geological Section, extending from the Blue Ridge at Tye River Gap to Cumberland Courthouse. Course SE. 68 miles.

The Blue Ridge at Tye river gap is composed of several mountains which unite with the main ridge on the eastern side, and by the road is 12 miles from the western to the eastern base.

Beginning at the western base of the mountain, we find the sandstones and slates of No. I. with a high dip to the N W. These rocks of No. I. occupy a small hill just west of the foot of the mountain, and extend a short distance up the side of the Blue Ridge; their width as exposed

Willis's mountain dip 20° to NW., while the Mica slates and Gneiss which surround it all have a dip, and generally a high one to the SE. - - - - - 1 mile.

From Willis's mountain towards Ca Ira the section passes over grey Gneiss with a high easterly dip, which are traversed by several ranges of Greenstone. About 2½ miles west of Ca Ira the section crosses a narrow range of red sandstone, which lasts nearly to the village. This range consists of red Shale and Conglomerate, and contains imbedded globular concentric masses of Greenstone. Dip of these red rocks is gentle to the SW., and the dip of the slates on each side is SE. They are evidently a deposite of not much depth, merely filling a hollow or basin in the Micaceous slates below, upon the edges of which they rest unconformably. The section crosses near the northern termination of this narrow range of sandstone, which continues south and west by Farmville to beyond Prince Edward courthouse, and there becomes associated with a black Shale containing seams of bituminous coal. - - - - - - 8 miles.

Between Ca Ira and Cumberland courthouse the rocks consist of grey Gneiss, sometimes arenaceous, with a gentle dip SE., as at Willis's river and Rocky run, and towards Cumberland courthouse they appear as white felspathic Gneiss, decomposing and furnishing much porcelain or china clay. Dip gentle SE. - - - 5 miles.

SECTION IV.

OF THE MIDDLE SECONDARY SANDSTONES, SHALES AND CONGLOMERATES OF THE SOUTHERN DISTRICT—EAST OF THE BLUE RIDGE.

CHAP. 1.

General Features of this Formation.

The rocks of the formation here referred to, though differing greatly among themselves as to the nature and mechanical condition of the materials of which they are composed, are distinguished from all others in this region by peculiar and well marked features.

In the first place they are obviously made up of the re-united materials of other and of course older rocks, in fragments of all dimensions, from the minutest grain to masses weighing many pounds, sometimes associated in strata of comparatively uniform texture throughout, and sometimes very heterogeneously assembled.

The coarser materials of these strata are distinct and easily recognized fragments of Granite, Gneiss, Hornblende slate, Mica slate, Epidote, Quartz and other rocks, such as are usually met with in the

wide belt of country extending from the eastern flank of the Blue Ridge to the head of tide, and stretching in a southern and southwestern direction through the Carolinas far into the state of Georgia. The more comminated matter is identical in composition with the grey, yellowish, red and particoloured sands and clays, produced by the decomposition of the rocks referred to, and which are to be met with very generally covering them to a greater or less depth.

All the larger fragments, and even the particles of sand entering into the composition of these strata, present more or less of a *rounded outline*. This feature is most strikingly displayed in such fragments as are of a nature to be readily worn by mutual attrition, or by the agency of moving water, as for example, Hornblende slate, Mica slate, Chlorite slate and Gneiss, all of which are usually met with in the form of oval pebbles, while the fragments of Quartz, a much harder rock, embedded beside them in the same mass, are seen to retain their sharp edges and projecting corners almost unaltered. In fragments of very large size this configuration is less conspicuously seen, though even these, while preserving much of their rectangular or polygonal form, exhibit unequivocal proofs of the same wearing agency.

While much variety is displayed in the colour of these strata as presented in different localities, the predominating tint of the entire range of the formation is a deep brownish red, not easily distinguished from the hue of those soils in the surrounding region, which owe their complexion to the decomposition of the prevailing Epidotic, Hornblendic and Trappean rocks. This more usual tint is often seen alternating with shades of grey, yellow and green, and in some cases over wide tracts is almost entirely superseded by them.

In general the conglomeritic structure, though of frequent occurrence, is confined to comparatively narrow portions of the belt occupied by these strata, the majority of the beds being made up of sandstones and shales, composed of siliceous and argillaceous particles mingled in various proportions, but in most cases the former being present in large excess. The loose coherence of these ingredients leading to the rapid disintegration of the strata when exposed to the weather or to denuding agencies, has caused their extensive destruction near the surface, and has imparted a glady character to much of the region over which they spread. As might be anticipated from the texture of the soil thus formed, as well as of most of the underlying rocks, the region of these shales and sandstones is deficient in bold and steady springs, and though covered with a soil of easy cultivation, and of some fertility in the lower levels, is peculiarly exposed to injury in seasons of drought.

Being exclusively of sedimentary origin, and containing at many points both animal and vegetable remains, the middle secondary strata would at first view appear to be closely allied to the sandstones, shales and conglomerates of some of the Appalachian formations as presented in the hills and valleys on the other side of the Blue Ridge. Geologically considered, however, they belong to a later epoch in the physical history of our continent than any of the groups of strata in that portion of the state, or even in the region extending thence to

some distance beyond the Mississippi. Of their position in the scale of secondary formations it will be sufficient for the present to observe that while the widely expanded coal measures of our Trans-Alleghany region which extend over our western counties and a large portion of eastern Ohio, and in virtue of successive gentle undulations, are again repeated in the vast coal basins of Indiana and Illinois and of Missouri, are admitted to occupy a station low in the series of secondary formations, and while another group of strata, including the green sand and rotten limestone of New Jersey and Alabama, exposed in certain districts of these states, as well as of Tennessee and Mississippi, and elsewhere, are placed in the highest position in this series, the rocks of which I am now treating bear evidence of an intermediate geological date, and hence have been denominated by professor H. D. Rogers and myself the middle secondary formation.

Before describing in detail the limits of the interrupted belt or series of large islands formed of the middle secondary strata in the southern district to which I am now particularly referring, it may be well to remark that in the explorations of a former season, the same formation was met with in the northern portion of the state in a nearly similar position in regard to the Blue Ridge, but though crossed at that time in various places in Culpeper, Fauquier and P. William counties, and examined with some attention in particular localities, the general objects then in view did not admit of a connected series of observations for determining its boundaries, and the various details relating to its structure and composition. But though these accurate results remain for the labours of another season, enough was then observed to furnish the means of comparing the formation there exposed with that recently explored in all its details in the southern district, and to give the fullest assurance of their identity. That it is not unimportant to have clearly ascertained this fact, will readily appear when it is considered that the formation as presented in the northern district of our state is prolonged into Maryland, stretches with little or no interruption entirely across that state and Pennsylvania, traverses New Jersey as far as the Pallisadoes on the North river, and there is every reason to believe is again presented in the valley of the Connecticut, while its southern portion in Virginia, after being interrupted near the state line, quickly reappears and extends in considerable breadth for some distance into North Carolina.

In comparing the strata of the discontinuous tracts occupied by this formation within our own borders, our deductions, founded upon an examination of the materials, structure and dip of the rocks, in all of which a striking resemblance is every where preserved, have been not a little aided by the occasional discovery of organic remains. Thus the black polished rhombic fish scales, found in the bituminous shales near Farmville, and at Leakesville in N. Carolina, and in Fauquier county, and the minute shells found in a dark slate near Flournoy's in P. Edward and at Leakesville, together with various impressions of vegetable origin, have served to give validity to the conclusion otherwise deduced of the identity of the formations at these remote positions.

The rocks of this formation in Virginia being confined to a belt of country removed to some distance eastward of the Blue Ridge, while, except in a single instance, the lower members of the Appalachian series no where spread eastwardly from the great valley into the same region, our middle secondary is never met with adjoining or overlying the Appalachian rocks, as is frequently the case in Maryland and Pennsylvania. This entire separation of the two is important in explaining the comparatively small amount of calcareous matter in the form of pebbles or minute particles contained in the rocks of that portion of the middle secondary which traverses Virginia. In New Jersey, Pennsylvania and Maryland, the shales of this formation are calcareous, and the coarse conglomerates are largely made up of pebbles of limestone identical in character with the beds of that rock appertaining to the Appalachian series, occurring in the adjoining and surrounding region.

The well known Potomac marble, a highly ornamental rock, composed in great part of such fragments, united generally by an intervening reddish shaly material of a more or less calcareous composition, though forming in Maryland a conspicuous portion of the middle secondary strata, and often occurring in thick beds in the same geological connection in Pennsylvania and New Jersey, is seen rapidly changing its composition as it is prolonged towards the south, presenting comparatively few limestone pebbles in Fauquier, still fewer in Culpeper, only here and there a single fragment in the neighbourhood of Barboursville in Orange county, and no massive and very little diffused calcareous matter in its extension through the counties south of the James river. Yet so marked a resemblance of the coarse conglomerates in many portions of this region in which they are almost devoid of calcareous matter to the Potomac rock, produced the similarity in the cementing material and in the non-calcareous fragments of the two, that at a little distance they might readily be confounded. As a striking instance of this general likeness, I would point the observer to the interesting series of exposures presented along the line of the James river canal for some miles below the mouth of Rockfish, in which the character of this conglomerate as it occurs in this portion of the middle secondary is finely displayed, not only on the faces of the newly bared cliff, but in the piles of large fragments on the river side of the canal.

A feature of much interest in the geology of this formation, is the almost universal prevalence of a NW. or NNW. direction in the dip of the strata, a fact which has been observed not only throughout the region more particularly referred to in this place, but at all the other exposures that have been examined within the state. The same direction of dip has been noticed by myself in these rocks in the southern part of Maryland and in North Carolina, and has been traced over a much greater extent of the formation by my brother professor H. D. Rogers, in the course of his minute explorations in Pennsylvania and New Jersey, where this group of rocks is developed on a wider scale.

This interesting fact viewed in connexion with the nature and mechanical condition of the materials composing these strata, sug-

gested to my brother early in his investigations in the states before mentioned, very important inferences, since fully sustained by my observations in Virginia as well as Maryland and Carolina, as regards the directions in which the powerful currents flowed while conveying the detrital matter to the region in which it was deposited as now seen layer upon layer in conforming slope, and the geographical position of the territory from whose surface these materials were washed and torn away. Without entering at large into these deductions, of which an extended account would be inappropriate in this place, it may for the present be remarked, that nearly if not all the matter of which these strata are composed, may with confidence be traced to the wide primary region lying to the south and east; the currents coming in from that direction, bearing with them the red soil and coarser materials so abundantly furnished by the Hornblendic and other rocks there extensively spread out. These transported matters would appear to have been conveyed into a prolonged estuary or trough having a general direction from SW. to NE., and being deposited in successive layers commencing at its southeastern margin, would naturally assume the attitude of strata dipping to the northwest.

It is not a little curious to observe that strata apparently appertaining to a corresponding formation in Nova Scotia and New Brunswick, and consisting of materials analogous to those of our middle secondary rocks, are described as very generally presenting the same northwesterly dip.

Before concluding this short sketch of the most interesting general features of the formation, I would call attention to what I consider the true explanation of the important fact, already incidentally mentioned, of the non-existence of limestone pebbles, or even of diffused calcareous matter in any considerable amount in these strata as presented in our southern counties. This explanation I conceive is found in the absence of calcareous rocks throughout the region lying towards the southeast of this portion of the formation. The bands or ovoid patches of Micaceous and Talcose limestone, ranging near the southeastern margin of the middle secondary in most of the belt of country through which it passes north of the James river, continuing their general direction nearly in a line with the long reach of this river between Scottsville and Lynchburg, make their appearance in the counties farther south to the northwest of this formation, at the distance of several miles from its nearest boundary. So long as any of these limestone beds are found extending along its eastern verge, limestone pebbles are to be met with in the conglomerates, and even where these beds have thinned away to an insignificant layer, such fragments occasionally present themselves. Moreover, the resemblance of these pebbles to the calcareous rocks from which they are supposed to have been derived, affords a striking confirmation of this view of their origin, and thus also furnishes a strong argument in favour of the inference of my brother, in regard to the direction in which the materials generally of this formation were transported. These facts considered, it would seem reasonable to conclude that the non-existence of limestone in the region lying to the southeast has been the cause

of the almost entire absence of calcareous matter in the southern portion of the formation in Virginia, and that in its prolongation south, this ingredient is not to be looked for unless where bands of limestone, having the required position, are presented.

CHAP. 2.

Boundaries of the Middle Secondary Formation in the Southern District.

In proceeding briefly to describe the limits of the formation as developed in this portion of the state, I would premise that the surface covered by it is not in the form of one continuous belt, although probably such was the case when the strata were first deposited, but consists chiefly of *two oblong tracts*, the one extending from the state line near the southeast corner of Henry county, with an intermission of some miles near the line, to a point a little below the mouth of Rattlesnake creek in Campbell county, thus covering the southeast angle of Henry county, passing entirely across Pittsylvania, and more than half way across Campbell, and in its course encroaching a little on the NW. angle of Halifax county; the other lying eastward of the prolongation of the former, traversing the northern part of Prince Edward county from a point about four and a half miles SSW. of the courthouse to the Buffalo river above Farmville, but broken in this distance by a wide interval in the neighbourhood of King's tavern, thence ranging through the southwest corner of Cumberland, and at the same time spreading over into Buckingham county, skirting Willis's river in the former, and terminating at a point about two miles north of Ca Ira.

A little northwest of the direction of the former of these tracts, supposing it to be prolonged, the formation again appears about a mile below Warminster on the James river, thence extending with an increasing breadth and a direction bending around more towards the east along the northeast corner of Nelson, covering a small strip on the south side of the James river, at its great bend, in Buckingham county, and passing through the adjoining corner of Albemarle, whence it continues into Fluvanna, where, within a short distance of the line, it terminates. The northeastern portion of this tract, or that lying in Fluvanna county, as well as part of the adjacent region covered by the same formation in Albemarle, not having yet been traced with sufficient minuteness for defining their limits, will be omitted in the following details.

Tract of the Middle Secondary lying in Pittsylvania, Halifax and Campbell Counties.

Measured from the state line to its termination in Campbell county, omitting the hiatus between the villages of Cascade and Bachelor's Hall, the length of this tract is about sixty-two miles. At its widest part, near Riceville in Pittsylvania, its breadth is rather more than six miles, but this does not continue long in either direction. Its ave-

rage breadth may be estimated as about four and a half miles. This therefore would make its area about two hundred and eighty square miles.

Beginning at the state line, the boundary of that portion of the tract south of the interruption before spoken of, which portion is in fact but a continuation of the formation which in North Carolina follows the course of the Dan river, passing through Leakesville, Sawratown, &c., may be traced by a line drawn about a mile east of Cascade creek and nearly parallel to it, passing through a point a little east of the village of Cascade, thence turning westwardly so as to cross the creek about five miles from the state line, and sweeping around to a southwestern direction, intersecting Smith's river near the same line.

Between the termination of this area on the NE., and the re-appearance of the formation at the SW. extremity of the White Oak mountain, is a space of about three and a half miles in width, in which only primary rocks are to be seen, though circumstances strongly indicate that the strata of the middle secondary once extended continuously across it, and have been removed by the violent denuding power of one of those currents, by which at various points the formation appears in former times to have been deeply lacerated or swept away.

Northeast of this interval, in the formation, its limits are marked out by a line drawn entirely around it in such manner as to have the directions and pass through the points enumerated below.

From a point about one and a fourth mile to the north of Bachelor's Hall, where the line is supposed to commence its course, is for some distance westward, then inflected in passing around the end of White Oak mountain, so as to form a curve, maintaining a nearly uniform distance (one mile) from the road leading to Dallas's bridge. Taking now a nearly straight course as far as Bannister river, it stretches along the northwest flank of the mountain about one mile east of Fitzgerald's and of Chesnut's store, crossing the river about the same distance below the mouth of White Oak creek. From this vicinity it assumes a more northerly direction, crossing Cherry Stone creek about two and a half miles above its mouth, passing on the east within two miles of Pittsylvania courthouse, (Competition on the map,) then about one mile east of the White Thorn tavern, where it crosses White Thorn creek, and thence turning still more to the north to the main road at George's creek, and after this with a sudden eastern bend to Chalk Level. Recovering its original direction by a quick bend; after leaving this point it crosses Staunton river a short distance above the upper end of Long Island, passes near the mill on Molly's creek, intersects the road leading from Campbell courthouse to Reid's bridge on Falling creek, about one and a half mile from the bridge, and with a very gentle curve reaches the northeastern extremity of the tract near the mouth of Rattlesnake creek on the same river.

Turning now to the south to form the boundary on the southeast, this line soon assumes a direction but slightly diverging from its course on the opposite side of the tract, passes miles west of Nowlan's, thence in a nearly straight course across Staunton river about half a mile below Pannel's bridge, thence with some gentle flexures to a

point to the west and within a half a mile of Riceville. From this point it bends gently around more towards the west, so as to diminish the width of this portion of the tract intersecting the road leading from Danville through Pleasant gap in the White Oak mountain, at the distance of about five and a half miles from Danville, and after a southeastern turn, which brings it within three quarters of a mile of the Dan river, sweeps around with rapid curve to the point a little north of Bachelor's Hall, where it commenced.

Tract of the Middle Secondary lying in Prince Edward, Cumberland and Buckingham Counties.

As already mentioned, this area is interrupted by a wide interval in the neighbourhood of King's tavern, extending for a distance of about two miles, measured in a north and south direction by a line passing through King's. The space thus bare of the middle secondary strata being occupied by Mica slate, Gneiss, Granite, Sienite and other rocks, altogether of a primary character.

A short distance south of the courthouse we come upon the northern margin of these strata, forming part of the boundary of a small oval patch whose greatest length, from NE. to SW., is not quite two miles. This on the east is marked by the course of the Briery river, which flows along and sometimes a little within its margin. On the west it extends to within from a half to three quarters of a mile of the main road from Charlotte courthouse to Farmville, having for its greatest breadth a line of about a mile in length, passing through a point known as Flournoy's coal pit.

The main tract of the formation in this part of the state, commencing about half a mile north of King's, is bounded on the west, as far as Buffalo river, by the road leading in a NE. direction from Hampden Sidney college to that stream, and on the east by a line nearly parallel to Buffalo creek, and distant from it about half a mile, terminating at the Appomattox river on the edge of Farmville. In the wedge shaped area between the Appomattox and Buffalo rivers, the strata of the middle secondary have been nearly all removed or covered by alluvial material, but north of the former stream they are again exposed for a distance of about one and a half mile, extending from a point upon the Bizarre estate about half a mile above Farmville, up the river to within a few hundred yards of the point marked on the map as Sandy Ford bridge. The tract north of the river has for its eastern boundary a line running nearly due north from the point on the Bizarre estate already referred to, passing a little west of the intersection of the Clover Forest road and that leading from the turnpike in a western direction to Dry creek, and crossing the former about a mile from the intersection just mentioned, then turning towards the east and running again northwards from a point about three quarters of a mile west of Raine's tavern in Cumberland, to near the intersection of Little and Great Willis's rivers, whence, with a nearly NE. course, it extends west of Ca Ira about a quarter of a mile, crosses Raine's creek near its mouth and reaches the northern extremity of the tract about midway between Raine's and Buffalo creeks.

From this point the line in question turns rapidly through a NW. to a SW. direction, crossing the Ca Ira road about a mile and a half from Ca Ira, intersecting Great Willis's river about a mile east of Kurdsville in Buckingham county, passing immediately east of Mrs. Hendrick's, and thence taking a nearly due south direction to the point below Sandy Ford bridge before mentioned.

The entire length of this irregular tract, from the most southern exposure of the strata in Prince Edward, to the most northern in Cumberland county, may be stated at twenty-two miles. Its greatest breadth, to wit: in the parallel of Kurdsville, is about four miles, and its average width approximately one and a half miles, making an area of about thirty square miles.

From these details in regard to the boundaries of the tracts in question, it is believed that by a careful reference to the state map, an accurate picture may be formed of their geographical position and extent, and I would respectfully recommend to such as are interested in the subject, to read the above details, pencil in hand, so as to trace upon the map the limits thus marked out.

CHAP. 3.

Characters and Contents of the Middle Secondary Strata in the Tracts above described.

Of the structure and composition of the rocks of this formation, as found in other parts of the state, and in other states, a general account has already been given, in the course of which also particular reference has been made to the chief peculiarity presented in the strata as developed in the tracts now under consideration.

For the more particular illustration of their character and contents, it will be sufficient for the present to select a few facts from the large body of details collected.

Commencing with that portion of the formation lying near the state line, and to the south and west of the village of Cascade, the prevailing rocks met with in crossing the tract are dark red, yellowish, and grey sandstones, and blackish slates, with but little rock coarse enough to be called a conglomerate.

The following details of a section from Cascade due west across the formation include the principal strata here met with:

1. A short distance east of the village, on a small run, occurs a bluish slaty sandstone, immediately adjacent to which, on the east, are heavy beds of coarse Granite.
2. Next we find a dark sandstone alternating with a dark compact slate, slightly calcareous.
3. Next deep red sandstone, very slightly calcareous.
4. Next a dark bluish brown slate, with layers of argillaceous sandstone, somewhat similar in hue.
5. Next fine red sandstone, argillaceous, and slightly micaceous, followed by a coarse red sandstone.

6. Next yellow slaty sandstone followed by soft red argillaceous sandstone of a fine grain, to which succeed the primary rocks bounding the formation on the west.

In the prolongation of these rocks in a southwestern direction into North Carolina, heavy beds of blackish soft slate or shale make their appearance, and are well exposed at the bridge over the Dan river just above the mouth of Smith's river. These shaly strata contain indistinct impressions of vegetables, and very perfect casts of a delicate bivalve shell, and are underlaid by several layers of hard slaty rock which is somewhat calcareous.

The dark colour and rather carbonaceous character of these shales has given rise to the opinion that they contain a valuable seam of coal, for the exploration of which operations have, it is understood, been actually commenced. At Linsey's, three miles above Leakesville, in shales of the same character, which are here observed frequently to alternate with red and grey sandstones, two shafts have been sunk in search of coal, and a small seam of dark carbonaceous matter has been explored, consisting of alternating layers of coal and slate, the aggregate thickness of the former probably not exceeding one foot. It is a non-bituminous coal, generally compact and lustrous, and bearing a striking resemblance to a very common variety of the Pennsylvania anthracite. Its composition in the 100 grains is as follows:

Carbon, - -	83.12
Volatile matter, - -	7.76
Ash, - - -	9.12

As from the partial success that has attended the explorations in the vicinity here referred to, some incentive might seem to be justly furnished for undertaking similar enterprises in parts of the same formation within the limits of Virginia, it was thought proper to direct particular attention to the above localities, notwithstanding they lie beyond the geographical boundaries of the state. I may therefore mention as the result of these enquiries, that from the facts observed, no reasonable hope can be deduced of finding either at the points referred to, or in the neighbouring portions of the formation in Virginia, any seam of sufficient thickness and extent to prove of real economical importance. The existence of carbonaceous layers containing small portions of coal, sometimes of great purity, at various points in the range of this formation, far from being improbable, is what might naturally be expected from the views already stated as to the origin of the materials composing the middle secondary strata in general. But looking to the fact already stated, that the rocks in question belong undoubtedly to a later epoch than that of the great coal formation of this and other countries, an epoch marked by the deposition of strata distinguished for their barrenness of vegetable as well as animal remains, no encouragement to expensive enterprises of research can be derived from these merely local, and as it were, accidental accumulations of vegetable matter.

Remarks similar in purport to the above, published in my annual report some years ago, were suggested by a mere cursory examination

of the formation as disclosed in Fauquier, Prince William and Culpeper, though at the time but an imperfect knowledge of the geological character of this formation had been attained.

The examinations since made in various parts of the middle secondary tracts in Virginia, as well as those of my brother in Pennsylvania and New Jersey, have only served to establish the truth of the opinion early formed as to their non-productiveness in coal to any valuable amount. It is therefore hardly necessary to remark that the same views are to be applied in regard to the indications of coal, and the thin seams of coal and carbonaceous matter met with at some places in the middle secondary strata of Cumberland and Prince Edward counties, to which particular reference will hereafter be made.

Recurring to the strata of the southern tract, and pursuing them north of the hiatus formerly noticed, we find them largely composed of dark and light grey sandstones, which with an intermixture of red slates and sandstones, constitute a considerable ridge called White Oak mountain. These rocks, spreading to some distance from the flanks of the mountain on both sides, and forming a glady and sandy region, are sometimes coarsely conglomeritic, a feature here as well as generally throughout the formation, most conspicuously displayed along its western verge. Of this, an interesting example is seen where the Dry fork, one of the branches of White Oak creek, is crossed by the road. The conglomerate at this point consists of large fragments of Granite, Gneiss and Quartz. At George's creek, near Chalk Level, this rock presents the curious character of a soft red sandstone variegated with yellow and white, in which are imbedded, as in a paste, large rolled masses and pebbles of light red Granite, flesh coloured Felspar, Talcose Granite, Gneiss, and red, white and blue Quartz.

Where the formation attains its greatest breadth, which is nearly in the line joining Chalk Level and Riceville, the following rocks are met with:

1. Commencing a little west of Riceville in descending the hill towards Bannister river, where the contact of the primary rocks with the middle secondary is beautifully displayed, the last of the formation is a greenish argillaceous slate, dipping very steeply to the south-east.

2. A little lower in the hill, and resting on the edges of this slate, we see the beds of sandstone and red shale containing imbedded fragments of Granite and other primary materials, dipping at a high angle to the northwest.

3. These continue until we come to strata of red shales and sandstone of finer texture in the valley of the river.

4. We then have red and grey and bluish sandstones, the two former containing fragments of Felspar. These continue alternating with little variation to near Chalk Level, where the primary rocks again recur.

Crossing the tract near its northern extremity in the direction of the road by Reid's bridge to Charlotte C. H., we meet with the following strata:

1. On the western side, red and grey sandstone and conglomerate, the first predominating, the last forming irregular masses, consisting of large pebbles of Quartz, Mica slate, Granite, &c.

2. Red shale and fine grained red sandstone.

Throughout all this tract, as formerly indicated, the dip of the strata is to the NW., the angle of inclination varying from point to point, being as much as 40° at the White Oak mt., 30° at Mt. Airy, 40° at Pannil's mill, and in general lying between 20° and 40°.

The rocks of the middle secondary tracts of Prince Edward, Cumberland and Buckingham counties, are for the most part identical in character and contents with those of the more southern tract just illustrated, the chief points of difference between them being the greater prevalence in the former of greyish sandstones and carbonaceous shales, containing impressions of shells and vegetables.

The following are the principal strata presented in crossing the tract north of the Appomattox river in a direction from Raine's tavern (Cumberland) towards Kurdsville:

1. Within one and a quarter mile of the tavern, we come upon the margin of the middle secondary rocks, here consisting chiefly of soft grey sandstone with some vegetable impressions, and a thin seam of impure carbonaceous matter exposed on the farm of William S. Walton.

2. Red and green shales and sandstones, hard and soft, appearing on the road in ledges for a distance of nearly two miles.

3. Yellowish and brown soft sandstones, and near Cook's mill a ledge of bluish slaty sandstone, containing a spiral univalve shell and the rhombic fish scale.

4. Yellowish and reddish shales and sandstones.

5. On the western margin of the formation nearly opposite Mrs. Hendrick's dwelling, an extremely coarse conglomerate.

The conglomerate here referred to, which also makes its appearance one and a half mile west of Lackland's tavern on Mr. Harrison's farm, and at other points in the same line, consists of large nearly angular fragments and large pebbles of primary rocks, cemented by a coarse red shaly paste. At Mrs. Hendrick's the imbedded masses are chiefly the following: Felspathic Gneiss, Hornblende Slate, Epidote, Granite, Quartz, and Hornblende Gneiss. Among which is to be seen a nearly prismatic fragment 2 feet long by 8 inches wide, as well as many others closely approaching it in size. The huge dimensions of these fragments, especially at the latter place, entitle the locality to rank among the geological curiosities of the state, and will not fail to excite the admiration of the observer when viewed as commemorating the mighty energy of the moving waters by which these enormous masses were torn away from their parent beds and transported to the position in which they are now found.

At numerous places in this tract the shales and sandstones present thin seams of carbonaceous matter, bearing much resemblance to the dead coal often seen at the outcrop of a true coal seam, and at some points a small amount of impure bituminous coal has been found. The nearest approach to a seam of valuable extent is presented on the land of Mr. Flournoy, situated near the southern extremity of the

small oval patch of middle secondary lying south of Prince Edward C. H. Here the seam, as explored by a small shaft, is associated with brownish sandstones and shales, and is said to have measured nearly two feet in thickness.

In borings at Morton's mill and on the Bizarre estate, the former descending to the depth of two hundred, the latter of ninety feet, similar dark shales and brownish sandstones were encountered, enclosing several very thin seams of bituminous coal. At the former place the shales are impressed with the rhombic fish scales, and the sandstones with vegetable stems and leaves, and these rocks, besides being slightly calcareous throughout, contain thin layers of impure limestone, a character, as formerly noticed, but rarely occurring in the southern portions of our middle secondary.

The thin seams of carbonaceous matter before referred to are found near the surface at col. Wilson's, Mr. Anderson's and Mr. Walton's, the locality before noticed, and appear to be of very common occurrence. Usually the material of these seams is a friable mixture of carbonaceous and earthy matter, seemingly intermediate between peat and coal, but in some places it has the character of a hard bluish black mass of rather porous texture, and inclining somewhat to a columnar structure, bearing a strong resemblance to a compact mass of coke. The fact hereafter to be adverted to of the very frequent occurrence of dykes of igneous rock in this portion of the middle secondary tract, would favour the opinion that the matter in question is but a modified form of the ordinary carbonaceous material caused by the high temperature of these rocks at the time of their intrusion among the middle secondary strata.

After a careful examination of various exposures in which these thin seams, as well as indications of coal are found in the tract in question, it may be safely stated that no facts have been met with to warrant a more favourable opinion of the extent of coal it contains than that already expressed under a preceding head, and as on first appearances the simulated coal seams above described may prove an enticement to mining adventures, I feel it to be my duty to discourage all enterprises of the kind as little likely to be attended with even partial success.

CHAP. 4.

Igneous Rocks occurring in the Middle Secondary Tracts.

At many points within the area covered by the sedimentary strata of this formation, we meet with beds of a hard, ponderous, dark coloured rock, remarkable for the rounded form in which it spontaneously separates when acted upon by the weather, as well as for the peculiar rusty coating and concentric structure of its exterior produced by the same cause. These beds, or rather dykes, far from constituting a part of the formation in which they occur, are due to totally different and for the most part later agencies. They are in fact the Trap or greenstone rocks of the geologist, and are igneous products,

bearing close analogy to some of the results of volcanic action. Instead of lying conformably with the neighbouring strata, and therefore in the tracts of which I am now treating, dipping to the north-west, they are found *rising through* the beds of shales and sandstones that enclose them, forming in some cases a distinct ledge or wall, and thus severing completely the connection of the opposite portions of the same bed. The strike or range too of these dykes, instead of being nearly NE. and SW., as is generally the case in the rocks around, pursues a course nearly at right angle with that direction, being for the most part about NW. and SE.

It would thus appear that subsequently to the deposition of the middle secondary strata through which they penetrate, these igneous materials have been forced in among them from beneath, filling, while in a molten state, the fissures created by the accompanying subterranean movements, and not unfrequently entering between the layers of sedimentary rock, or pouring out and overspreading them at the top.

As might be expected, the effects of intense heat are often strikingly exhibited by the strata adjacent to these dykes, and as many curious examples of these effects are to be met with in our middle secondary region, it will not be deemed inappropriate to enumerate the more important of them in this place. They may be thus briefly described:

1. A great induration of the sedimentary material, so that from a soft shale or sandstone, it is converted into a hard sonorous mass, yielding with difficulty to the hammer.

2. A greater or less obliteration by a partial fusion of the separate constituents of the rock, thus incorporating the various particles, and even fragments of considerable size, so completely as to render their recognition as originally distinct, difficult and sometimes impossible.

3. A marked change of colour, owing to the chemical combinations induced.

4. The development of distinct crystalline matter, sometimes sparsely, sometimes abundantly, through the mass, so that what was formerly a mere aggregate of red sand and clay, becomes a bluish or greenish rock, studded with beautifully perfect crystals, produced by the chemical union in definite proportions of certain ingredients of the shale or sandstone originally only mingled in a loose mechanical way.

Without pausing to describe the various instances in which our middle secondary strata evince the modifying effects of adjacent igneous rocks, I will content myself with citing a single but conspicuous example.

This is to be seen on the James river a little above Warren. The middle secondary, whose eastern margin crosses the river from the hill below the ferry house to a point a short distance below Warren is here composed of alternating beds of red shale and coarse red conglomerate, containing rounded fragments of Quartz, Epidote, Hornblende slate and other primary materials, ranging N. 50 east, and therefore very obliquely to the stream, the harder of these beds, the conglomerate, is seen crossing it in numerous parallel ledges for a distance of several miles, thus forming what is called Goldsby's falls. *bout* half a mile above the ferry house on the Buckingham side, the

igneous rock presents itself in a bold hill, and is seen in broken ledges and enormous fragments stretching over to the opposite bank in a direction nearly perpendicular to that of the other rocks, thus causing its appearance there at a much greater distance up the stream. It is a very hard and rather coarse grained Trap, of a dark grey colour, arising from the mixture of a nearly black Hornblende, with a small proportion of Felspar. Where measured, its breadth is about 200 yards, but evidently diminishing as it extends northwest.

The shales and sandstones adjacent to this dyke on both sides of the river present various degrees of alteration, evidently depending upon the more or less refractory nature of their materials and their relative proximity to the dyke. On the sides of the hill, and therefore almost in contact with the trap, their metamorphosis is so complete, that nothing short of the actual tracing of the gradually increasing change of structure, would justify the conviction that they are but modified conditions of the loose sedimentary rocks found at a little distance on either side. Masses of Epidotic rock, consisting of a hard bluish grey matrix with kernels of bright green crystalline Epidote, a similar rock in which the crystalline material is less fully developed, conglomerates in which the pebbles seem to have been almost melted together, red shales converted into a purple rock profusely spotted with white kernels of crystalline matter, so tough and hard as scarcely to admit of being broken, are among the materials met with at this point, evincing the influence of the dyke. Indeed so entirely changed are many of these rocks that no trace of their sedimentary origin is retained, and judged of by hard specimens they would be pronounced to belong to the class of primary rocks of undoubted igneous production, while in fact, to use a new term expressive of the conversion which they exemplify, they have only been *primarized* by the vast mass of igneous matter intruded among them.

The following descriptive list of specimens of these altered rocks will appropriately close the remarks upon this subject:

1. Fine grained red sandstone, indurated with kernels of a white mineral.
2. Purple rock, of great hardness, with crystalline specks. An altered shale.
3. Red sandstone much indurated with some Epidote.
4. Do. with much Epidote.
5. Coarse sandstone much altered, apparently by a partial fusion, very hard.
6. Altered sandstone, with kernels of Epidote and micaceous iron in small scales.
7. Altered sandstone consisting of grains of Quartz dispersed through Epidote.

SECTION V.

OPERATIONS OF THE SURVEY IN THE GREAT WESTERN COAL REGION.

CHAP. 1.

General Sketch of the Structure and principal Rocks of the Region.

In conformity with the plan proposed in the beginning of the present report, the regions next claiming attention are,

First. The coal basins situated between the Front Ridge of the Allegliany in Hampshire and Hardy counties, and the ridge called Laurel Hill in Monongalia county.

Second. The wide tract lying west of Laurel Hill and its prolongation south, and the Ohio river, and

Third. The district watered by the Great Kanawha and its tributaries, extending from the irregular eastern escarpment of the formations associated with the coal, as far west as the Ohio.

Of the first of these regions I propose presenting a somewhat detailed description, but of the two others it would be premature, in the present stage of our investigations, to attempt any systematic account, and in regard to these therefore I shall do little more than give a brief sketch of the progress of our investigations, and present some important local illustrations adapted to shew the nature and bearing of certain interesting results already attained.

As the widely extended surface of these regions, and indeed of the whole of that portion of the state lying west and north of the eastern escarpment of the rocks immediately associated with the coal, comprises groups of strata, for the most part superior in geological position to the highest member of the Appalachian series described in my two last reports under the title of formation XI., it will be useful, before entering into particulars as regards the geological features of any portion of the wide region under consideration, to describe, in a general way, the principal groups of strata by which it is overspread, as well as the more prominent facts relating to its structure, developed in the prolonged axes, occupying a large portion of its surface.

Bearing in mind the descriptions given in former reports of the numerous, successive and generally abrupt undulations exhibited by the strata in almost every part of our Appalachian region, and the prolonged lines of parallel anticlinal and synclinal mountains and valleys, thus disposed in alternating arrangement upon its surface, we are not surprised at finding similar variations in the positions of the strata continued for some distance beyond the margin of the region in which the higher and more western groups of rocks appear.

These anticlinal axes met with in our great western coal region, preserving a parallel direction with those of the Appalachian belt, give rise to ranges of mountains less elevated above the general level of the surrounding region, and broader and less abrupt in their declivity than the ridges formed by the more steeply inclined strata of the Appalachian portion of the state. Yet, as might naturally be an-

ticipated, along the summits of these broad mountains, the mantle of rocks appertaining to the coal formation, once evidently continuous in its extension over the inferior strata, has been more or less removed; and thus over their undulating tops and in their profound ravines and river gorges, the upper groups of strata belonging to the Appalachian series, are not unfrequently deeply and extensively exposed. The destructive rush of waters, whose denuding power is so clearly attested by the removed summits and gashed sides of so many of these broad ridges would seem, after tearing away the stouter materials above, to have met with far less resistance from the soft shales and sandstones, forming the interior mass. Hence would appear to have originated the deep valleys and abrupt hills by which the space included between the flanks of these ridges is so generally characterized, and hence the deeply scooped channels of those streams, which are permitted, not merely to pass through, but to meander for great distances along the central line of the axis and in the very heart of the mountain, whose interior structure they thus contribute to disclose.

Of the topographical and geological features here described, numerous exemplifications are met with in that portion of the great western coal region nearest to the western margin of the Appalachian belt, more especially towards the northern limits of the state, while over the wide districts lying still farther west, the few low undulations which occur, ultimately become lost in the gentle and almost imperceptible inclination of the strata towards the valley of the Ohio. Hence throughout this more western portion of the area occupied by the strata appertaining to the coal, even the uppermost of the Appalachian rocks is no longer to be met with any where upon the surface or in the deepest natural or artificial exposures that exist. The rocks belonging to the principal coal measures, in their turn also become buried as we approach the Ohio in the region of Parkersburg and Point Pleasant, giving place upon the surface to shales and slates and sandstones, either destitute of coal or containing it in thin and variable beds. These gently sloping strata thus gradually depressed, again rise to the surface as we proceed still farther to the west, thus bringing into view, over a wide and affluent belt of country in the neighbouring state of Ohio, the counterparts of the lost coal seams and their associated beds of sandstones, slates, shales, iron ores and limestones in an order the reverse of that in which they had been seen to disappear in Virginia, some distance east of the Ohio.

As necessary to the general picture of this wide spread series of rocks, it may be added that beyond this belt of productive coal measures in Ohio, as we descend to the valley of the Scioto, we come in view of a group of underlying east-dipping sandstones, slates and limestone, corresponding to our upper Appalachian formations, so that comprehending in one wide view the whole series of strata, comprising and lying at no great distance beneath the coal rocks of this wide region, and leaving out of consideration the undulations previously alluded to as occurring towards the eastern margin of the tract, we are presented with the imposing scene of a *vast synclinal trough or basin* spreading from the eastern escarpment of the coal

rocks in Virginia, entirely across the western portion of the state and the eastern half of Ohio, and terminating there in a similar escarpment in which the rocks are seen inclining towards the east to meet their counterparts dipping in an opposite direction in Virginia. It is a little westwards of the centre or lowest line of this enormous basin, that the Ohio river pursues its course for most of the distance in which it forms the western boundary of our state. But another feature is yet to be introduced to complete the general outline of this interesting region. The eastern and western margins of this basin, though nearly parallel about midway of its length, gradually approach each other as they extend towards the north, and thus bending round. the former in Pennsylvania, the latter in Ohio, at length actually coalesce and form the head or northern termination of the trough. As a result of this configuration it will at once be seen that along this northern boundary of the basin, the coal rocks must have an inclination towards the south or in the direction of the length of the vast trough, while the Appalachian strata underlying them beneath this northern escarpment will be seen dipping beneath the basin in a corresponding direction.

Fortunately for the resources of the valuable though small tract including the three counties lying between Pennsylvania and Ohio, this northern termination of the trough takes place at no great distance north of where our territory begins. So that the Ohio in its course along the western margin of that tract intersects the southerly dipping strata in a direction highly favourable for the development of their rich mineral contents, and exposes along the Virginia as well as the Ohio shore, nearly all the seams of coal, and beds of limestone and other valuable materials, required to complete the series of strata appertaining to the vast coal basin through which it flows.

From this general outline of the great western coal field of which Virginia possesses so large a share, it will at once be seen, that leaving out of view the numerous important undulations of the strata before referred to, the higher rocks in the series present themselves successively, dipping beneath the surface as we recede from the margin of the basin towards its middle, from whatever point of this margin we may take our departure. Each stratum of the vast series of the coal measures may in truth be regarded as an immense oblong bowl or trough whose longer diameter has a direction nearly NE. and SW., terminating at the northern end, near the Ohio and Pennsylvania line, and gradually widening in a somewhat oval form as it passes through Virginia and Ohio. Near its widest part, it is obvious, the Virginia and Ohio portions of the margin would be parallel to each other and to the longer diameter, and would therefore have a direction from NE. to SW., but in the progress of its expansion, all the directions between that of its northern end and the one just specified would successively obtain; so that following it along the eastern margin, we should have it SE. and NW., S. and N., SW. and NE., and perhaps within the limits of Virginia, approaching Kentucky and Tennessee, WSW. and ENE. We may therefore regard a series of such bowls, similar in form and fitting the one within the other, as giving a general representation of the

stratification of the entire region we are considering, neglecting for the present the irregularities occasioned by the undulations in the neighbourhood of the eastern margin.

Bearing in mind this inelegant but perhaps not useless illustration, it will at once appear that a river entering the margin of the basin and flowing entirely through it, will penetrate in succession each of the inner bowl-shaped strata on the one side, and then passing across the innermost, and therefore the uppermost of them all, will again penetrate the same beds, but in an inverted order—and if, as in the case of the Ohio, we suppose it to enter near one of the extremities of the oblong trough, and to flow nearly along but a little west of its central line, we shall have exposures of all the strata from the northern margin to the highest bed of the series, those only excepted, which forming the very innermost and uppermost of the concentric strata, present their western margins to the east of the valley of the river. These, as is really the fact, would be found capping the hills at some distance eastward of the river, and presenting both their eastern and western margins on the Virginia side. To complete the application of this rude analogy to that portion of the great trough of coal-bearing strata through which the Ohio flows, the varying developments of the rocks caused by its frequent and important changes of direction, claim also to be considered. If while flowing through the highest or innermost of the strata accessible in its general course, and thus pursuing a direction nearly from NE. to SW., it should be diverted from this line so as to take a direction towards the west or NW., it is obvious that this would lead it away from the inner and higher strata, and carry it across some of the subjacent beds, while a change in the opposite direction would convey it into still higher strata lying to the east, and if continued for a sufficient distance, might carry it through them to pass into the eastern or Virginia sections of the lower strata. It is thus that the river in that part of its course extending from near the NW. corner of Tyler county to the bend a little above Marietta, flowing nearly in the central line of the trough, exposes only the upper strata, but bending towards the NW. as it approaches Marietta, it displays strata a little lower, and thence pursuing a direction nearly parallel with that first mentioned, it passes Parkersburg in a line several miles west of what may be regarded as the axis of the trough, still continuing to display nearly the same rocks as are met with at Marietta, until by another and more important flexure to the NW. below Letart's falls, it plunges more deeply still into the strata west of the middle of the trough, bringing to light in a position sufficiently elevated above the river to be productively mined, the important coal seam wrought on the Ohio side, and known as Pomeroy's seam. Continuing with numerous flexures its general southwestern course as far as Burlington, and keeping very nearly in the same rocks, the coal of which is again exposed below Gallipolis, it bends around to take a direction bearing it across the western portion of the basin, after which traversing in succession lower and lower strata of the coal measures, and presenting a noble development of rich coal seams and iron ores on the Ohio and Kentucky sides, it emerges from the basin near Portsmouth and pursues its way through the Appalachian strata lying to the west.

I have thus, at the risk of tediousness and repetition, endeavoured in a familiar manner to describe the general features of our great western coal region, in the hope that the more important relations of its strata as to direction and position may be clearly conceived, and that thus erroneous views as regards the general extension of the more important coal seams may be no longer entertained—and I have been thus minute in exemplifying the configuration of the strata included in this vast basin, and the various modes in which they are exposed by the noble river which pursues its way along and through them, from a belief that some general plan or pattern elucidating the great features of structure thus particularly dwelt upon would aid the reader in comprehending the more local descriptions which are to follow.

As an important preliminary to the details about to be presented in regard to the structure and contents of a portion of the wide area above referred to, I now proceed to give a brief account of the more important groups of strata found within its limits. And since, as already stated, some of the upper portions of the Appalachian series are repeatedly brought to light within the confines of this region near the northern border of the state, and as they moreover form the basis on which the coal rocks are seen to rest along nearly the whole of the eastern margin of the great coal field, it will be found useful briefly to advert to the peculiar features by which they are distinguished where adjacent to the coal rocks in both of these positions.

FORMATION X.

Of the various axes hereafter to be described, occurring within the eastern margin of the great area of coal rocks, but one has yet been found south of the Maryland and Pennsylvania lines, and north of the deep gorge-like valley of the Dry fork of Cheat river, in which the formation here referred to has been sufficiently elevated to be brought distinctly into view, while in both of the states just mentioned not only this but formations IX. and VIII. still lower in the Appalachian series, are developed in considerable extent by the expansion of some of the Virginia axes as they are prolonged towards the northeast. Of the existence of the formation in question, in the middle and southern parts of Randolph county, no opinion can as yet be formed, as our explorations in the northern part of the coal region have not been prolonged to any great distance south of the fork of the Cheat river before mentioned, which traverses the county in a NW. direction. Along this stream, which flows in a profound transverse trench across several axes hereafter to be described, not only this but the two subjacent formations IX. and VIII. are in part exposed. But minute examinations still further to the southwest have clearly shewn that in none of the axes there presented has this formation been elevated to the surface. Indeed, throughout this part of the eastern margin of the coal region, the undulations are extremely gentle though of great breadth, and merely sufficient, where aided by the deep trenching or denudation, here giving the wildest irregularity to the outline of the eastern *escarpment* of the coal rock, to bring into view the formation lying

immediately beneath (XI.), and between them and that of which I am now speaking.

Along the eastern slope of the Alleghany front ridge in the northern part of the state, and its continuation in the lofty range separating Pendleton from Randolph county, the rocks of this formation may be seen generally about midway up the mountain. They here consist of coarse white and reddish sandstones, often containing pebbles, greenish and reddish micaceous sandstones of a slabby structure, and conglomerates consisting of white pebbles embedded in a dark brown or a greenish paste. At many points the coarser sandstones, as well as the micaceous fine grained rocks, are rich in impressions of vegetable stems and leaves, usually converted into bituminous coal, and in some places within these limits a very thin seam of impure coal is interposed, though continued only for a short distance.

In Pocahontas and Greenbrier counties this formation thrown a little west of its original direction by the rising of new axes in the Appalachian district, is seen skirting the Greenbrier river to near the bridge a few miles east of Lewisburg, presenting in general the same characters as above described, but including at various points, as for instance on the river west of Huntersville, a conglomerate of remarkable coarseness, in which whitish pebbles, sometimes two inches in diameter, are embedded in a brownish and greenish paste. As followed in this direction, its thickness, though fluctuating, is very much augmented, as will appear from the fact that while on the Potomac below Westernport, where the river makes a transverse section of the Dan mountain or Alleghany front ridge, it measures only about 200 feet across in a direction perpendicular to its lower and upper bounding plains, in the vicinity of Lewisburg its width is about 800 feet. It may also be remarked, that with this increased development of the formation thus locally presented, we find, as has been noticed in numerous other cases in regard to the same group of rocks, a corresponding development of the thin seam of coal included in it, as occurs in the vicinity of Lewisburg, though here as in most other parts of the formation the amount and quality of the coal are not such as to repay exploration, except for immediate neighbourhood purposes, and indeed but rarely even for these. West of the exposures near the Greenbrier river, it is not again brought up, excepting over a narrow space in the low anticlinal hill called Brushy ridge, which separates the levels from the valley of Sinking creek. It is here flanked on both sides by the overlying limestone of the formation next to be noticed.

Of the character of formation X. as presented in several of the axes in the northern part of the state, particular mention will be made in treating of that district under a subsequent head.

FORMATION XI.

The group of shales, sandstones and limestones included in this formation constitutes the upper member of the Appalachian series of rocks as systematically described in my two preceding reports. Resting upon the upper surface of X. they are well disclosed along the

front ridge of the Alleghany in Hampshire and Hardy counties, occupying the higher portion of its eastern slope, and dipping with a moderate inclination towards the northwest, so as to pass beneath the strata of the coal basins lying in that direction.

Further towards the south, the calcareous as well as the other parts of this formation become more widely developed, owing in part to an increased thickness in the rocks, and in part to the influence of several axes west of the front ridge, which by repeated turns retain the formation longer at the surface. Entering Pocahontas county near the head waters of the Greenbrier river, the lower strata are seen skirting the river generally near its western margin, the windings of the stream carrying it alternately into the rocks of X. and of XI. The increasing thickness of the formation, together with the great flattening of its dip, as we trace it south, cause it to overspread a wide area in Greenbrier and Monroe counties, throughout a large part of which the calcareous portion of the formation is seen imparting to the surface the undulating outline and the productive soil usually met with in limestone regions.

Still farther towards the southwest, we find it occupying the eastern slope of the Blue Stone mountain, and with a very gentle inclination towards the northwest, dipping beneath the coal rocks of the Great Flat Top mountain, which with a gentle slope in the same direction spread continuously thence towards the valley of the Ohio.

In Tazewell and Russell, wherever met with, its general character and position are found to be unchanged, but the long lines of dislocation by which the southwestern portion of our state is so wonderfully marked, in numerous instances conceal this and several of the adjacent Appalachian formations, pressing up to the very margin of the coal rocks, strata far lower in the series, and even crushing these rocks and their contained seams of coal, folding them together and turning them over into inverted dips.

Having in my two preceding reports described somewhat at length the various strata included in the formation now in view, it will be unnecessary to enter into similar details at present. I will therefore content myself with stating, as characteristic of the formation wherever met with in Virginia, the occurrence of beds of limestone near the bottom, the prevalence of red and green soft decomposing shales above, and of brownish and greenish sandstones near the top. I may also add the very common occurrence of small rounded concentric grains the size of mustard shot, or a little less or greater in certain bands of the limestone, and the very frequent presence of a thin seam of coal, or of bituminous slate, where this formation adjoins the overlying conglomerate or sandstone of XII.

To display the nature and relative extent of the several strata forming this group, as exposed at points very remote from each other, and thus to illustrate the remarkable expansion especially of the calcareous portion of the formation as developed west of the Greenbrier river in Pocahontas and Greenbrier counties, I annex the following details of measurements made in the course of our explorations during the past season, the one along the margin of the Potomac below

Westernport, where the river intersects these strata nearly at right angles, the other from near the mouth of Stamping creek in Pocahontas county up the slope of the Greenbrier mountain, where, in the form of a lofty escarpment of nearly semicircular form, it overlooks the beautiful limestone valley of the Little Levels.

Thickness and character of the several strata of formation XI. on the Potomac below Westernport:

Commencing with the highest group of strata which are seen extending nearly to the top of the lofty hill, whose capping beds of sandstone have received the name of the Horse rocks, and proceeding in the order of their position to the several underlying beds as far as the upper limits of the next inferior formation (X.), we have the following results:

1. A mass of sandstones and crumbling shales of a deep red colour, with occasional bands of a greenish tint. Towards the top the beds are more siliceous and less deeply tinged, but lower down they assume the soft shaly character and the peculiar rich red colouring characteristic of this part of the formation. Thickness, - - -	650 ft.	
2. A bed of limestone, the highest rock of this description in the group. It contains fossils, and is conglomeritic, consisting of pebbles of limestone cemented by a mixed calcareous and shaly paste, -	4	6
3. Light grey freestone, slightly calcareous, -	2	7
4. Red shales, generally argillaceous and crumbling,	97	8
5. Red and grey variegated sandstone of a slabby structure, - - - - -	6	2
6. Red argillaceous shales, - - -	78	6
7. *Siliceous limestone,* with oolitic bands, containing at bottom 18 inches of pure light grey limestone,	46	7
8. Red shale and sandstone, with bands of limestone,	15	5
9. *Siliceous limestone,* remarkable for its diagonal lamination, and for the coarse grains of sand standing in relief on its weathered surfaces. This latter character, caused by the removal of the calcareous matter from around the grains, is so striking, that though often a pretty good limestone, so far as applicable to the making of lime, it presents the aspect of a light grey and coarse freestone, and might readily be mistaken for such. It is however an inferior rock to (7),	10	4
10. Red limestone, rather siliceous generally, but in parts of pretty fine grain, - - -	6	0
11. Pinkish marble, - - -	1	0
Total thickness,	918 ft.	9 in.
Thickness of calcareous rocks about - -	80	0

Small as is the proportion of the calcareous rocks to the other strata displayed in this locality, it is found still to diminish as we proceed north, until as stated by my brother, professor H. D. Rogers, in the interior of Pennsylvania, at some points, the limestone bands are entirely wanting. The following details will serve to shew how greatly these limestones are augmented in thickness as the formation extends towards the southwest:

Thickness and character of the strata of formation XI., as measured from the mouth of Stamping creek to the top of the Greenbrier mountain, Pocahontas county:

1.	Sandstones and shales, the former predominating towards the top, the latter lower down. The general colour of the shales is a rich brownish red, with occasional interpolated greenish bands. Texture of the shales crumbly, composition chiefly argillaceous, with a little calcareous matter. The more siliceous rocks above are red and grey, slightly micaceous, and including shaly bands. They are readily divided into slabs, and are rarely of a coarse texture. Thickness, - - - - - -	1260 feet.
2.	Blue and grey limestone, with argillaceous shaly bands occasionally interposed. Some of the strata wonderfully rich in fossils. Near the top of the limestone occurs a flinty or cherty layer, also full of fossils, - - - - - - -	822
3.	Red argillaceous crumbly shales, - -	50
	Total thickness,	2132 feet.

On comparing the two measurements thus given in detail, we see that not only has the entire thickness of the formation augmented in extending towards the southwest, but the relative amount of limestone has increased in a still higher proportion, the former having expanded to about 2½ and the latter to 10 times its thickness, as seen upon the Potomac.

The interesting results of this change in the character and extent of this formation are well seen in the richly productive surface of the Little and Great Levels, the valley of Sinking creek, and the wide limestone region of Monroe county, which are geologically but the counterparts of the narrow band of limestones and calcareous shales lying along the eastern declivity of the front ridge of the Alleghany in the northern portion of the state.

As might be expected, much variety is displayed in the composition and character of the different bands of limestone belonging to this formation. Nor is there much constancy in the same band as exposed in different localities, as will appear from the analyses given towards the close of the present report. While some of these rocks are remarkably pure limestones, burning into a white lime of the finest texture, others contain a large admixture of carbonate of magnesia as well as of silica, and often also oxide of iron; and by trials recently

made, furnish *a water cement* of good quality. A large number of similar analyses are yet to be made in regard to these rocks as exposed in the axes of the Cheat, Laurel Hill, and other ridges within the limits of the great coal region, as well as over the wide area of calcareous rocks developed in this formation farther south.

Iron ores are of frequent occurrence near the upper limit of the formation, more especially where it is met with in the axes before spoken of, and often exists in such amount, and of a quality so rich and easily wrought, as to possess a high degree of economical importance. Of the composition of these ores, which are usually protocarbonates of iron, some examples will be given hereafter, and a large number of further details will be gathered in the progress of our chemical investigations.

FORMATION XII.

Having thus, in some detail, described the various strata belonging to the two upper formations of the Appalachian series, more particularly with the view of affording the means of identifying them as they are presented within the limits of our great coal region, and in the hope also of rendering the description of a portion of that region hereafter to be given, clearly intelligible to the reader, I proceed now to treat of the first of the series of rocks immediately associated with the coal, and upon which repose all the slates, sandstones, limestones and coal seams comprehended under the denomination of the coal rocks.

This formation, strongly contrasted in its general aspect and composition with the preceding, which lies immediately beneath, consists of a group of whitish or light grey sandstones, generally of a coarse texture, and comprising heavy beds of conglomerate, usually conspicuous for the white polished round pebbles of which it is mainly composed. The loose and open texture of these coarser rocks, causing them to crumble by long exposure to the weather, occasions the disengagement of the pebbles, which are thus seen profusely strewed over the surface in many places where this formation occurs, becoming in fact a useful geological land-mark where the rock itself is concealed from view.

This beautiful white gravel is met with in great abundance, accompanying the massive strata of the conglomerate, high up on the eastern front ridge west of the upper termination of formation XI.

The same coarse rock, with its attendant pebbles, is found in a similar geological position on the Backbone of Alleghany, on the Cheat mountain and Laurel Hill, as well as several other minor ridges. It is also well displayed on the summit of the Big Sewell and various knobs and ridges of the adjacent region, and forms the nearly level capping of the Blue Stone mountain and its continuation further to the southwest. Every where along the margin of the great coal region, this formation may be seen, marking the transition from the upper member of the Appalachian series of rocks to the widely expanded groups of strata with which the coal seams are associated.

It is not however to be inferred that at all points it displays the same conspicuous conglomeritic structure, or is developed to the same thickness, for in both these particulars it presents frequent and important fluctuations, passing from a mere mass of large rounded pebbles cemented by siliceous matter, chiefly at their points of contact, to a conglomerate of shot-like gravel, and thence to a coarse, and in some cases, to a fine sandstone of even and compact texture, and in thickness varying from a thousand, and perhaps more, to a hundred, or even less than a hundred feet.

Nor in all cases does it throughout maintain the character of a purely siliceous rock, for instances occur in which bands of slaty sandstone, and even bituminous slate, accompanied by one or more seams of coal, are included between the coarser and more massive strata of the formation. Yet with all these variations, the general characters of the group as above described, are sufficiently definite to enable the practised observer to recognize it when it appears, and its features usually are so well marked that a glance is sufficient for this purpose.

It will readily be seen, from what was before stated in regard to the general arrangement of the strata, in and adjoining the coal region, that the upper position, geologically, of this or any other group of rocks, does not necessarily imply an actually greater elevation above the general level of the region, compared with rocks geologically inferior. The positions as to height of the various rocks of the great basin, or of any of the axes within its confines, is greatly determined by the extent to which they have resisted, or yielded to the denuding agencies, to which, as formerly illustrated, they have been every where more or less exposed. On this account the formation of which I am speaking is often absent for great distances along the top of an anticlinal mountain, while low down upon the flanks of the ridge it may be seen in enormous blocks, or thick continuous strata dipping away in opposite directions from the enclosed and underlying beds of XI., while the latter rising in undulating hills along the intervening space, tower far above the strata which once extended as a connected covering entirely over the mountain from side to side.

It will at once be inferred from what has now been said as regards the geological position and usual characters of this formation, that as a general rule, explorations in pursuit of coal should be directed to the series of strata, lying *above* it in geological position, and that where the outcrop or margin of the conglomerate may be clearly traced, we are to be governed by the direction in which the strata dip, in selecting the line most suitable for our examinations. Where for example these strata are seen inclining downwards towards the NW., we would take our departure from the margin of the basin marked out by the beds of conglomerate, and travelling in the direction of the dip, or towards the NW., we would enter upon the upper and coal bearing strata lying within, and thus successively encounter the coal seams and their accompanying rocks in the order of their superposition. It should be observed, however, that in applying this rule it is of course presumed that the route thus pursued is along a line which, if not horizontal, descends towards the centre of the basin at a less angle

than the dip of the conglomerate and overlying rocks, for otherwise we might continue upon one or other of these beds throughout nearly the whole of our course; or, if following a line of very deep denudation, might penetrate below the conglomerate into the formation which lies beneath.

The remarkable expansion and diversified character assumed by this formation for some distance within the margin of our great coal field in the western parts of Pocahontas and Greenbrier counties, has caused it there to overspread a wide area, and to include along with the usual beds of conglomerate numerous beds of slate and sandstone, varying in hue and texture, together with seams of coal of sufficient magnitude and purity to be esteemed worthy of exploration. Of the exact limits of this remarkably diversified group of strata, it is as yet impossible to speak with confidence. The undulating directions of the beds and the topographical peculiarities of the country having presented difficulties in the way of a precise solution of this problem, which can only be removed by further examination. This much, for the present, may be stated, that the coarse and partially conglomeritic sandstone composing the celebrated cliffs of New river, skirting that stream on both sides for some distance in the form of lofty mural precipices, and prolonged with a northwesterly dip, so as to constitute the wide sheet of nearly level strata over which the Kanawha is precipitated at the falls, is to be regarded as occupying the same place geologically with the similar strata forming the general margin of the region occupied by the coal bearing strata; and in confirmation of this view it may be added, that the series of sandstones, slates and coal seams so admirably exposed in the lofty hills extending along both sides of the Kanawha to some distance west of Charlestown, and which have been ascertained to overly this conglomeritic rock according to a nearly invariable order, are in all important features analogous to the group of coal bearing strata elsewhere found resting next above formation XII. It would therefore appear probable that a part, if not all the coal seams associated with the rocks of the Big Sewell mountain appertain to a lower group of coal rocks, forming a portion of the formation of which I am treating, here widely expanded and wonderfully diversified in its characters. But as already stated, further investigation is required to determine with exactness the true boundaries of this formation, and therefore the true relations of the various rocks in question.

FORMATION XIII.

Under this head it is deemed convenient for the present to include the whole of that diversified series of rocks comprising sandstones, fine, coarse and conglomeritic, slates, shales, limestones, and seams of coal, which occupy nearly the whole of the wide area lying beyond or west of the formation just described.

In remarking upon this formation no attempt will be made to give a minute account of the more important groups of strata which it comprises, as such a description, even though it were partial, would

involve an amount of details incompatible with the design of the annual reports, and as moreover much further examination is requisite in nearly all portions of our great coal region to enable me to present its economical and geological characteristics in the ample form necessary to render a description of them satisfactory and useful. I shall therefore confine my observations under this head to a general account of the formation as presented at different and remote parts of the region, with the view of illustrating some of the more important modifications by which it is affected in extending from tract to tract, as well as of indicating certain important landmarks among the very numerous and variable strata of which it is composed, adapted to furnish us with valuable aid in assigning their true limits to the chief subdivisions of the formation, as well as in conducting our explorations for practical purposes on sure principles and to useful results.

Throughout the larger part of the entire thickness of this formation, commencing at its lower surface, or where it rests upon No. XII., the rocks are chiefly of a decidedly siliceous character, consisting of sandstones of various textures, from the finest grit to coarse conglomerates, generally containing some, and often a large amount of mica, presenting considerable variety of hue, comprehending blended tints of grey light brown, and greyish green, and in some cases almost pure white. Associated with these are layers of limestone for the most part of a dull bluish-grey, but sometimes of a dark brown and nearly black tint, and generally shewing an ochreous aspect on the weathered surfaces. These beds, as met with in Virginia, are rarely more than a few feet in thickness, varying in this respect from point to point, and not unfrequently losing themselves by gradual transition into slate or iron ore, or sandstone. Numerous beds of slate also interpose themselves between the siliceous rocks, presenting for the most part a dark brown or nearly black, and an ochreous greenish colour. It is with these, particularly the former, that the coal seams are in general immediately associated. The bands of iron ore also usually occur in or adjoining them, as well as contiguous to the layers of limestone.

Towards its upper limits rocks of a less arenaceous character predominate. The sandstones which still occur in heavy beds are of a softer and in general finer composition, and the slates assume the form of argillaceous shales of a crumbling texture and deep reddish colour, alternating occasionally with green and ochreous tints, presenting a striking general resemblance to the shales of IX. and XI. of the Appalachian series. In this part of the formation the calcareous beds in general occupy a far greater thickness than below, imparting a richly productive character to the region over which in some portions of the great coal tract they are widely spread out. Calcareous matter is also present in considerable amount in the associated shaly strata, which are therefore in general marked by a productive soil.

Near the highest strata of the formation little or no coal is met with, but among the beds next beneath occurs one and in some cases two coal seams of great value, as well on account of the usually good quality as the abundance and continuity of the coal. It is in this geological position that we meet with the celebrated Pittsburg coal in

Pennsylvania, and, as hereafter will be shewn, the valuable seam explored in the hills at Wheeling, Morgantown, Clarksburg, and numerous intervening points. The two principal seams in the Potomac basin, to be noticed in the sequel, are evidently referrible to the same position.

Besides the general differences here noticed in the nature and aspect of the materials predominating respectively towards the lower and upper portions of the formation, important modifications in the composition and degree of development of its several subdivisions are seen to occur as we trace them from one portion of the great basin to the other, some of which, from their economical importance, as well as their general occurrence, merit a brief notice in the present sketch of the formation.

One of these changes is exhibited in the increased coarseness of the materials forming the arenaceous strata of the lower parts of the formation as traced from the northern limits of the state to the valley of the Great Kanawha, and at the same time the greater preponderance of the sandstone strata occasioned by their increasing thickness in that direction. This fact is well exemplified in comparing the rocks lying between the western base of Laurel Hill in Monongalia county, and their counterparts along the Kanawha, from the falls as far down as Charlestown. The comparatively small amount of slaty strata along the latter section, though fortunately unaccompanied by any diminution in the thickness or deterioration in the quality of the coal seams there so admirably exposed for long distances continuously in the river hills, would appear to connect itself with the attenuated width of the bands of iron ore occurring among these slates, and therefore would seem to give a general confirmation to the conclusion derived from our observations thus far, that these ores are much less abundant in that than in some of the more northern divisions of the coal field.

In the calcareous strata, especially those appertaining to the higher subdivisions of the formation, an equally marked alteration is exhibited. As followed in a southwesterly direction from the Pennsylvania line, these beds spreading widely over the tracts lying to the west of the Monongahela, are seen gradually becoming thinner by the interposition of strata of variegated calcareous shales, until over the western parts of Harrison, Lewis and Kanawha, as well as nearly all of Wood, Mason, Jackson and Cabell counties, a small and variable remnant of these rocks is met with, forming thin bands among these shales, which have now almost entirely usurped their place. As a striking illustration of the remarkable change here noticed, reference may be made to the expanded thickness of the limestone strata in the hills bordering the Ohio, in the vicinity of Wheeling, where these rocks appear to have attained their greatest developement as compared with the thin and variable seams of calcareous rock encountered in the region between Charleston and Parkersburg on the one hand, and Guyandotte on the other. Of the real extent and frequency of these small bands, further observations are requisite to enable me to speak with confidence; the region in which they are met with hav-

ing, as yet, been but partially explored. They will, however, receive that attention which, from their local importance in connection with ordinary and agricultural uses, they are believed to claim.

From what has now been said in the way of a general sketch of the prevailing characters exhibited in the lower and upper portions of this formation, as well as the interesting modifications occurring in each as developed in distant portions of the coal region, it must be apparent that the whole formation admits of being conveniently divided into two great groups of strata, each comprising sandstones, slates, shales, limestones and seams of coal, but yet sufficiently distinguished from the other by the predominating features above described. Adopting such a division therefore as conducing to greater clearness and simplicity in the economical as well as geological illustrations hereafter to be given, I shall for the present designate them respectively by the titles of *the lower coal series* and *the upper coal series.*

It cannot fail to be remarked, that in the perplexing and laborious investigations which are so often undertaken with the view of discovering or tracing the coal seams or other strata of the region under consideration, great assistance would be derived from the knowledge of some one bed or stratum, whose continuity over wide areas and constancy in position with regard to the other rocks, had been satisfactorily demonstrated. For in a region so broken, as is much of that of which I speak, and in which the strata present frequent though gentle undulations of dip, and often bear a strong resemblance to each other, the attempt at tracing them by an imperfect system of levelling, aided by rude computations of the angle of dip, is likely in many cases to lead to results not only erroneous, but prejudicial to individuals and the public.

It is on this account therefore that in the course of our operations in this region, as thus far carried forward, I have made it a leading object in the first place to acquire the necessary data for drawing, with some degree of accuracy, wherever possible, the line of separation between the lower and upper coal series, as well as for tracing the more valuable coal seams or other useful deposits, by reference to some *standard bed or stratum*, whose persistency over wide areas has first been satisfactorily established.

Our observations thus far in regard to the rocks towards the middle of the formation, would seem to shew that, between the upper and lower series, there is generally interposed a greater thickness of strata, barren of workable seams of coal, than either above or below, but of the constancy of this fact it is impossible to speak until I have completed a number of measurements proposed to be made at various points in the coal region, nor would a feature of this kind, unless exceedingly distinct, be of much avail to those who are interested in explorations for coal. Some mark more definite in its nature should, if possible, be determined. Such a one, I am happy to say, has been found to exist in that portion of the coal field which is traversed by the Kanawha river, and though not discovered until some time after the commencement of our operations during the last season, it has already enabled us to obtain a clear knowledge of all the general, and

most of the minute features of that highly interesting and valuable part of the basin.

The land-mark to which I here allude, and which was first recognized, and afterwards diligently traced by my brother prof. J. B. Rogers, consists of a band of black or bluish black siliceous rock, approaching the character of a flint or hornstone, which is found in the hills at the height of several hundred feet above the river near the falls, and which, accompanying the subjacent strata in their various undulations, and their ultimate steady western dip as they extend down the river, is seen to disappear below the water level at the Elk river shoals.

This stratum, from its striking peculiarity of character, and its constancy of geological position, furnishes a standard line with which to compare the rocks and coal seams both above and beneath, and may be regarded in this region as clearly defining the boundary between the upper and lower series. As will be seen hereafter, throughout the tract extending from the falls to the point at which the flint comes down to the river level, no seams of coal, but such as are local and of insignificant extent, occur in the hills above this stratum, but as we proceed towards the west, and thus in virtue of the westerly dip of the rock, pass successively into strata, higher in the geological order, we meet with one or more coal seams associated with the shaly rocks already noticed as predominating in the upper series.

The discovery of this, or some equivalent band, in other parts of the coal region, is a result greatly to be desired, and will, it is thought, be attained during the operations of the coming season. Towards this, as well as other interesting determinations, more especially relating to that portion of the region which lies adjacent to Pennsylvania, the minute researches now making in the corresponding section of that state, will contribute much valuable assistance; nor is it unimportant to the practical as well as purely scientific results, aimed at in the researches in progress in these neighbouring states, that by unity of method, harmony of views, and co-operation in the field, my brother and myself, are enabled, in various ways, to promote the accurate and expeditious prosecution of our several tasks.

In concluding this brief sketch of the general features of our great coal field, a few remarks may properly be annexed in explanation of the modes of exploration, thus far adopted and hereafter to be still more extensively employed in carrying forward our investigations in this region.

Having now acquired an accurate general acquaintance with the outline of the region, and having in some districts studied with much minuteness the most important rocky strata with their included coal seams and other deposites, it will be our object to trace the several beds composing the lower and upper series, from tract to tract, with the view of identifying particular seams, and forming correct ideas of the extent of territory over which each is of workable dimensions, and in a position to make it accessible above the level of the streams. At the same time a careful attention will be given to the bands of iron ore, as well as the limestones accompanying the coal. In the execu-

tion of these tasks it is evident that in many cases accurate measurements will be demanded, requiring proper instruments to be taken into the field. Among these the boiling point thermometer, of which, as a means of measuring heights, I have, for the last two seasons, made successful use in various parts of the Blue Ridge, and the Appalachian region, and during the past summer among the hills bordering the Kanawha, promises to afford us great facilities, and when aided by the common instruments for levelling, will enable us to continue our tracings with all the accuracy and expedition that could be desired.

CHAP. 2.

Of the Coal Basins situated between the Front Ridge of the Alleghany in Hampshire and Hardy Counties, and the Backbone Mountain.

In the preceding general sketch, allusion has been made to the occurrence in this portion of the state of several anticlinal axes, in the principal of which strata are met with appertaining to formations geologically lower than those properly belonging to the series with which the coal is associated. By referring to what has already been said in illustration of the arrangement of the rocks in the entire coal region, viewed as one continuous oblong trough or basin of vast extent, it must at once be evident that *between* any two such axes rising within the area of the coal region, the rocks including the coal must dip in opposite directions, so that as they slope downwards along those sides of the ridges which are facing each other, they will have directions which if prolonged would cause them to meet about midway in the intervening space. Each stratum thus reposing on the flank of one of these ridges has its counterpart lying with an opposite inclination on the flank of the other, and thus the whole of the space between the two ridges is made up of *trough shaped* beds, lying one within the other, and all of them obviously *superior*, geologically considered, to the rocks of which the ridges themselves are composed. It is further evident that where these ridges by gradually flattening out and becoming broader as they are prolonged in either direction, are thereby caused to coalesce, the concave bend of the strata between them growing less and less, must eventually be lost, and one mountain being formed of the two, the intervening rocks must disappear, and a rounded termination be given to the trough. This change taking place at both extremities, a true *basin* would be formed, in which the strata containing the coal would be found enclosed in a rim of the underlying formation, not only along their length, but around the curved margins by which they were united at the ends. Such is the character of the several small basins of which I am about to treat, though from the length of some of them they are only in part included within the limits of Virginia.

GENERAL LIMITS OF THESE BASINS.

The axis known in Pennsylvania and Maryland as Will's creek mountain, and which is traversed by Will's creek a short distance to the west of Cumberland, presents in the admirable section there disclosed a broad anticlinal arch of formation IV., flanked on the west by the successively higher groups of the Appalachian series, all maintaining a northwestern dip, and presenting as we ascend from the deeply denuded valley immediately west of the mountain, the various strata of VIII., IX., X., XI. and XII., forming the hills lying at the eastern base of the Dan mountain, and the eastern slope of that mountain nearly to the summit. Parallel to this margin of westwardly dipping XII., we meet a few miles farther to the west with another rim of the same formation, inclining in the opposite direction, and forming the crest and a small part of the eastern slope of the Savage mountain. In the intervening tract occupied by a series of lofty and picturesque hills, occur the coal measures of the basin in which Frostburg, Lonaconing and Westernport are situated. In this region the Savage mountain presents only easterly dipping rocks, displaying in succession along its western slope the formations underlying XII., and separated from what is called the Alleghany, lying still farther to the west, by a wide region in which these formations downwards as far as VIII., are exhibited in anticlinal order, capped on the east by the conglomerate of XII., forming the top of Savage, and on the west by a similar rock forming at many points the summit of the Alleghany.

As we trace this basin towards the south, we observe a small change occurring in the axis lying to the east, which now becomes the axis of the Knobly mountain in Virginia, the Will's creek axis proper, having died out a little to the south of Paddytown where it crosses the Potomac, and that of the Knobly, which first shews itself a few miles south of Cumberland, having now assumed great breadth and elevation. The latter axis, lying a little east of the line of prolongation of the former, displays the same groups of strata, flanked on the western side by formations successively higher in the Appalachian series, until as we ascend the front ridge of the Alleghany, which is our Dan mountain, we pass from the upper part of XI. into the margin of the coal basin, marked by the conglomerate of XII.

The axis lying to the west of this basin, and between the Savage and Alleghany mountains in Pennsylvania, and marked on the map by a line a little west of the course of the Savage river above the mouth of Middle Fork, gradually flattens in its dips as we pursue it towards the southwest, and the country at the same time becoming topographically higher, we find the Appalachian rocks gradually disappearing between the Savage and the Alleghany mountains as we ascend in the direction of Crab creek in Maryland, and when we have reached the Northwestern turnpike, the two mountains have completely coalesced, forming the broad, nearly level ridge which, under name of the Backbone of the Alleghany, divides the waters of the North Branch from those of the Youghioganey. This wide table land, covered by the conglomerate of XII., extends to the head waters of

the North Branch, and in the vicinity of Fairfax's stone, sweeps around to coalesce with the same formation, which by the termination of the small basins hereafter to be described, is laid bare over the lofty wedge-formed tract comprised between the head waters of Red creek and Blackwater creek, tributaries of the Dry Fork of Cheat, and the Alleghany front ridge near the western corner of Hardy county.

But the basin thus included towards the north between the Savage and Dan mountains, and in Maryland and Virginia between the front ridge of the Alleghany and the Backbone, begins to present marked undulations in the dip of the strata in the region lying between the North Branch and Crab Tree creek, even as far north as the road leading from the mouth of Savage obliquely over the Backbone. The two rolls which are here distinctly to be seen acquire greater importance as they are followed towards the southwest, presenting at length two well developed anticlinal axes, and thus dividing what farther north is but a single basin into three minor basins, all of course lying between the front ridge and Backbone of Alleghany.

The *eastern of these two axes* crosses the North branch between the mouths of Abraham's creek and Stoney river, and extending along the western side of Abraham's creek in the direction of that stream, unites with the front ridge about 3 miles south of the old Moorfield road. The upper part of the conglomerate (XII.) is exposed on the North branch a little below the mouth of Stoney river, displaying some undulations, but farther down presenting a uniform NW. dip, thus pointing out the western side of the axis here referred to. The conglomerate, as we follow it down the river, in virtue of the inclination just mentioned, and the passing of the river flowing nearly in an easterly course, farther into the axis, attains the summit of the ridge about 2 miles above the mouth of Abraham's creek, and allows some of the shales of formation XI. to come into view between it and the level of the stream.

This axis thus forms the broad flat ridge which throughout its course separates the waters of Stoney river from those of Abraham's creek, and by its union with the front ridge before mentioned, terminates the basin to which the latter stream and its branches are confined. Before this union, for a distance of 5 or 6 miles, it is known by the title of *Spruce Ridge*, and is covered by the conglomerate of XII. in enormous masses of a thick tabular form. The coal field thus included between the front ridge and this axis, being obviously continuous with that lying along the North branch between the mouth of Abraham's creek and Westernport, may be denominated the *Eastern or Potomac basin*, and as will hereafter be seen, retains a larger number of coal seams, and more really valuable coal than either of the two remaining basins lying west of it and between it and the Backbone.

It may be well to bear in mind that the central line of this basin passes across Abraham's creek about half a mile to the east of the junction of Johnny Cake with that stream.

The *western axis* is the broad flat anticlinal ridge dividing the waters of Difficult creek and Stoney river. Lying but a short distance

west of the axis just described, the intervening tract which may be called the *Middle basin* is much narrower than either the eastern or western basins, and as will be inferred, presents only those rocks and coal seams lying next above formation XII. This shallow concavity in the strata is prolonged in the direction of Stoney river towards the wide area of elevated land in which that stream originates, and which as already described is overspread by the strata of formation XII., and even at this remote point the synclinal or trough-like position of the rocks is not entirely obliterated, though here as well as in the southern prolongation of the other basins, displaying only very gentle dips.

As will be inferred from what has been already stated, between the axis just described and the summit of Backbone, is situated the third or *western* of the three basins described as intervening between the front ridge and Backbone of Alleghany in this portion of their course. This western axis is by far the widest of the three, as compared by a transverse line crossing them all within the limits of Virginia. It here includes the waters of Difficult creek and those of the North branch from its sources to near the mouth of Abraham's creek.

As this and the middle basin are produced by the two great wrinkles in the strata before described as commencing east of Crab Tree creek in Maryland, their width and the depth of coal rocks they contain continue to increase as we trace them south, until they attain their maximum width within or near the limits of our state—and thence continuing south are terminated by the wide area of formation XII. lying in that direction. The great width of the western basin is also in some degree due to the great flattening of the dips of the strata around its western margin, to which also, as already described, we are to attribute the union of the Savage and Alleghany mountains as they extend through Maryland, to form the Backbone of Alleghany near and within the Virginia line.

With the view of ascertaining whether the two axes just described, as well as the broader and more important one of the Backbone of Alleghany, were continued into Randolph county, a continuous series of observations was made in that county along the Dry fork from the Horseshoe in a southwesterly direction to the eastern slope of the front ridge opposite Petersburg in Hardy county.

The Backbone axis, trenched deeply by the Cheat, exposes in the interval between Mill creek and Blackwater, several of the upper Appalachian formations.

The lowest of these, formation VIII., is well displayed along the central line of the axis a little south of Wolf run.

As we cross the strata towards the east, this formation dipping to the SE. disappears beneath the red slates and shales of IX., which in turn gives place to the overlying X. and this to XI., the calcareous or lower part of which is the highest rock met with in this part of the route.

This limestone belonging to formation XI. first shews itself about half a mile east of the mouth of Blackwater creek, dipping gently to *the SE.* and thus indicating that it appertains to the eastern side of the Backbone axis.

Still continuing our southeasterly course, we see it supporting the heaving strata of red shale forming the upper portions of the formation, gradually bending in a trough-like form so as at length to present a *northwestern* dip, clearly marking the continuance of the structure of the westernmost of the three basins before described among the lower rocks in their prolongation towards the southwest. Capping the bold hills through which the river here finds its way are the massive beds of formation XII. reposing in the form of a very shallow basin on the shales and limestone just described.

Some distance higher up the stream, but west of the mouth of Red creek, we pass through the limestone of XI. and strike upon X.—here a coarse conglomerate, and forming an anticlinal axis, obviously the feeble continuation of that formerly described as intervening between Difficult creek and Stoney run, and separating the *middle from the western basin.*

Still farther east, we have another synclinal or trough-like roll of the limestone, the eastern margin of which crosses the Flanigan settlement 2 miles west of the mouth of Red creek. Of course its dip here is to NW.

Succeeding and underlying this we have X. and IX. which arching over so as to form an anticlinal axis, and being again followed by XI. lying upon the east-dipping X. of this axis, give us the representative of the ridge separating the waters of Stoney run and Abraham's creek, in other words, that which *separates the eastern from the middle basin.*

We now ascend the western slope of the front ridge, presenting east-dipping limestone overlaid by the red shales of XI., and reaching the top, we find it occupied by a shallow synclinal trough of formation XII., *all that remains of the most eastern of the three basins.*

Thus are we admitted along this route to trace the undulations of the strata, which give origin farther north to the several basins intervening between the front ridge and the Backbone of Alleghany, and to obtain confirmatory evidence, were such required, of the existence of the structure which has already been described as seen within the area occupied by the coal rocks themselves.

Whether these axes are continued much farther to the south, and there develope in the intervening troughs enough of the overlying rocks to include one or more of the lower coal seams, is a problem which can only be resolved by the exploration of this portion of Randolph county in a future season.

EASTERN OR POTOMAC COAL BASIN.

It has already been remarked that as we proceed westwards from the margin of our great coal region, the axes of disturbance met with occur at much wider intervals, forming broader undulations, attended with more gentle dips. This well marked feature, evidently referrible to those mighty subterranean movements, whose influences were most powerfully impressed upon the various groups of rocks occupying the Appalachian region, is beautifully illustrated in the comparatively steep inclination of the strata belonging to the most eastern of

the minor basins now under consideration. Nor is it an uninteresting fact that the depth thus given to the basin, even where it is contracted to an inconsiderable width, has been instrumental in conferring upon it the great economical advantages it possesses. For it will at once appear that by this means the bottom of the trough was rendered sufficiently low to admit of the whole, or nearly the whole, of the rocks appertaining to the productive coal measures, lying upon the central or deepest parts of the trough, without towering to such an altitude as to be exposed to the destructive torrents which have robbed so large a portion of the area of our coal region of the coal seams and other valuable deposits once spread continuously over its surface.

Within this basin, as trenched by the North branch of the Potomac river, the lofty hills on the Virginia as well as the Maryland side expose to view at various points the lowest of the coal seams belonging to the true coal measures, and the principal and most valuable seam appertaining to the upper group, so that in fact they present to our observation at once the entire *lower* and the most valuable part of the *upper coal series*, as formerly distinguished.

Though striking variations are met with in the thickness and character of the beds interposed between the seams of coal at distant points, and though the smaller and lower seams are seen alternately thinning out and re-appearing, the more important ones probably maintain sufficient uniformity of character and thickness, to be identified wherever they occur.

At least five seams extend throughout this part of the basin, the largest of which, known as the 12 foot seam, occupying the highest position, is generally found near the summits of the hills. In the vicinity of Westernport, where it is well exposed at numerous openings, some of which are on the Virginia side, its elevation above the water is between five and six hundred feet. The breast of coal which it exposes varies from 9 to 14 feet, including bands of slate and impure coal in the upper 3 or 4 feet. It is a *semi*-bituminous coal, as is the case with all the seams of this and the other basins near the eastern margin of the coal region. From its great elevation in the hills, it is not only rendered more difficult of access than the lower and thinner seams, but is of course spread over a comparatively limited area, and is moreover in some cases liable to be injured from the insufficient protection of the strata by which it is covered.

The *lowest seam* in this basin is found in the bed of the Potomac, a short distance below the mouth of Savage river. Above it rest heavy beds of coarse sandstones, sometimes conglomeritic. Ascending the river above this point we find the coal and sandstone gradually rising, until at Brantzburg the former is seen at the height of about 20 feet above the water, having a thickness of 2 feet 11 inches of good coal.

The *second seam*, which at the mouth of Savage is seen near the water's edge, though not exposed immediately at Brantzburg, is met with in the vicinity having a width of about 20 inches.

Below the coarse sandstone, as well as immediately above and beneath the second seam are beds of olive and greenish shales and sandstones, containing above that seam a band of rich iron ore 6 inches

thick. The second seam here referred to, though occurring at other points, as will hereafter appear, gradually thins out as we trace the basin towards the south, and is wanting in the basins lying west of that now under consideration.

The *third seam*, known as the 6 foot seam, is well exposed near the mouth of Savage, in the slide, at a height, according to our measurements, of 156 feet above the river. At Brantzburg, the intervening rocks having become much thinner, its height is only about 75 feet. At this point the seam is divided into two parts by a band of slate 6 inches wide, leaving 3 feet 6 inches of good coal below, and 2 feet 11 inches of coal above, the upper 6 inches of which is slaty.

This seam, from the quality of the coal, its thickness, and its comparatively accessible position, as well as the wide area over which it may be wrought, is to be looked upon as one of the most valuable in the basin.

Above this there exist in the central parts of the basin from 2 to 3 other seams, known as the 5, 8 and 12 foot seams, the latter of which from its general exposure near the tops of the high hills, is the best known. Of the constancy of the occurrence of the 5 and 8 feet seams, farther observations are required before an opinion can be given. The exposures in which these seams are reputed to display themselves are few in number, and have as yet been imperfectly connected with the upper and lower seams, but the subject is of such importance as to justify special explorations, with the view of deciding upon their position and character.

As we proceed up the North branch from Brantzburg, seam (No. 1) is seen at short intervals on both sides of the river, but affords no good opportunity of examination on the Virginia side before reaching the estate of Mr. Samuel Harvey, about 6 miles below the mouth of Abraham's creek. Here it displays a thickness of 2½ feet, and lies at a height above the river of 14 feet, this interval being occupied by 8 feet of argillaceous shales, immediately underlying the coal, and 6 feet of slabby sandstones of an olive colour extending to the margin of the river.

Higher up the hill, seam (No. 2) is exposed with a thickness of 2 feet 2 or 3 inches, and at a level 75 feet above the former. This intervening space is occupied by 30 feet of shales resting on 45 feet of sandstone, through which in some places there runs a band of slate containing good iron ore, at some points 18 inches in thickness, though very variable, and thinning out with the enclosing slate.

On the Maryland side a short distance below this, seam (No. 1) is shewn, sometimes separated from the overlying sandstone by a band of shales of very variable thickness, containing iron ore of fine quality, in some places as much as 8 inches in thickness. Above this exposure, and higher up than the level at which No. 2, not seen at this point, ought to occur, a rich nodular ore occurs in considerable quantity interspersed in shales.

At Wilson's mill, about 2 miles below the mouth of Abraham's creek, the sandstone overlying (No. 1) presents frequent undulations, but with a prevailing dip towards the SE., indicating a position rather

west of the central line of the basin. Though it does not rise high enough just at this point to expose the coal, it brings to view the band of slate before mentioned as occurring at Harvey's lower down the river, and containing as there rich nodular iron ore, the nodules varying from one to twelve inches in diameter. The shales overlying this and separating it from seam (No. 2) are siliceous, coarse, and lead coloured, and abound in iron ore, rich but of a coarse texture. Seam (No. 2) is too thin to be worth working.

On the hill side near the mill, (No. 3) crops out, and the same seam has been opened on the Maryland side at an equal elevation. It is between 4 and 5 feet in thickness.

Higher up the river (No. 2) is repeatedly seen from 10 to 12 inches thick, and slaty. The shales both above and below contain the nodular ore, the nodules in the former being sometimes 18 inches in thickness.

Above Brantzburg the exposures of seam (No. 3) are rare in the hills along the river, owing doubtless to the covering of debris, but up Abraham's creek a seam is opened which is inferred to be (No. 3) from its elevation and the rocks adjoining it. It is opened about 3½ miles above the mouth of the creek, and again several miles above at Mr. Vandover's, where it is reputed to be from 4 to 5 feet thick. The same seam there is reason to think occurs on the western flank of the front ridge, a little north of the turnpike, on the estate of Mr. Johnson Covan. It is here near the eastern outcrop, and having a dip conforming with the slope of the hill, is kept too near the surface to be well preserved, but a little further within the basin there will be depth enough of covering to afford a sound coal.

The range of hills intervening between the river and the front ridge, and known as the river hills, are generally of sufficient elevation to contain the main or 12 foot seam, except where interrupted by deep transverse vallies leading to the river. This seam has been identified at numerous points both on the Maryland and Virginia side, between the opening nearly opposite Brantzburg and Elk Garden. The latter tract is situated in a slight depression between the river hills and the front ridge at the head of a valley which as it extends northwards becomes so deep as to separate these hills from the ridge. It commences about 2 miles north of the lower road crossing to New creek, from which point the hills are seen to increase in elevation as we travel south, thus tending to counteract the rise of the coal as it approaches the southern termination of the basin. In the neighbourhood of Mr. Vanmeter's, they reach their greatest altitude, and thence as they continue towards the south decrease in height to the valley of Abraham's creek. Here this stream, above the mouth of Johnny Cake creek, cuts through the hills, forming a little south of the turnpike a gorge, to the south of which the hills are too low to contain the main seam, as from our near approach to the southern extremity of the basin, the lower seams, the only ones here known, are raised to a much greater elevation than at points farther towards the northeast.

Though the Elk Garden tract overlooks the neighbouring hills both to the north and south, the gradual rise of the coal in extending to-

wards the south, brings the main seam here nearer to the summit of the hills, and thus contracts the area over which it can be worked.

From the mouth of Savage to that of Abraham's creek, all the seams of the basin are to be met with in the hills, excepting (No. 1), which below Brantzburg lies a few feet beneath the water, and the only diminution in the value of the tract as we approach the southern of these two limits, arises from the diminished area over which the main seam can be worked.

On the estate of Mr. Vanmeter, situated in the Elk Garden, where it attains its greatest height, the main seam was examined along its western line of outcrop. It consists of 12½ feet of coal with a covering of slate 3 or 4 inches thick, upon which rests 8 or 10 inches more of coal. Between 6 and 7 feet below the main seam are two others, the upper 20 inches thick, the lower 12, separated by 6 or 7 inches of slate.

In the vicinity of Mr. Covan's, the front ridge presents a very gradual descent to a narrow glade bounded on its western side by a low hill, near the summit of which the main seam occurs.

This is a short distance to the north of the turnpike and near Abraham's creek, on the estate of Mr. Shillingberger. Lying near the top of the hill, and having little or no dip, it will be workable only over a narrow area in this neighbourhood, but will no doubt be procured in a sound condition by driving into the hill, as there is depth of covering there sufficient for its preservation.

South of the turnpike this basin presents but two seams, viz: (No. 1) and (No. 3), the intervening thin seam having apparently fined out in extending towards the south. As we are now approaching the margin composed of formation XII., we are of course to look for none but the lowest seams. The upper of these (No. 3) is the one chiefly worked. On the estate of Mr. Kitzmiller, situated on a branch of Abraham's creek, one mile east of the mouth of Johnny Cake, it includes 3 feet of good coal, overlaid by 18 inches of slaty coal, and covered by soft argillaceous shales.

The same seam has been opened on the estate of Mr. Vandiver, just above the mouth of Johnny Cake, where it is 3 feet thick, but impure throughout, and having near the bottom the appearance of being partially coked. About 3 feet above the seam is a band of slaty coal resembling lignite. This is a very usual accompaniment of (No. 3.)

This seam has also been opened on Abraham's creek, 5 miles above the mouth of Johnny Cake, on the estate of Mr. Micle. It is now concealed, but said to yield between 2 and 3 feet of good coal, having a dull surface and looking like cannel coal. Throughout this part of the basin, as might be expected, the dip is towards the NW., for we are here east of the central line. A seam agreeing with this in character and association, and no doubt the same, is exposed a short distance south of the Moorfield road, both on the east and west forks of Abraham's creek.

A *lower* seam (No. 1) is also met with towards the southern termi*nation of* the basin, but has not been explored. At Mr. Vandiver's it

has been found to be good coal, and is situated at some distance below the other seam, (No. 3,) before mentioned as occurring on his estate.

As already intimated, additional explorations are yet to be made in some parts of this basin, having a special view to the seam or seams next beneath the 12 foot seam, the obscurity of the exposures thus far met with having precluded any decided inferences as to their position, continuity or thickness.

MIDDLE BASIN.

In this as in the corresponding part of the last basin, there are but two seams of coal. These by the associated rocks, as well as the character of the coal, shew themselves to be the same with the two found in the southern portion of that basin. The upper, which is every where the thicker seam, has been opened on the estate of Mr. Nevil, on Stoney river, about 2 miles below where the turnpike crosses that stream. It here yields about 3 feet of good coal, over which lies a thin seam of slate, and then about one foot of impure coal. Above the seam is a very thick bed of sandstone exposed to the height of 20 or more feet, a seam of very fine grained slate sometimes coming in between the sandstone and subjacent bed, but not uniformly present. As a general feature, the rocks of this basin are remarkable for their variability in thickness and composition. As one instance of this, I would cite the fact that only one mile further up the river the seam of coal just mentioned is overlaid by slates and shales. At this locality it yields about 2 feet of good coal, over which is about 18 inches of impure slaty coal. At a still higher level occurs a vein of impure iron ore, which for more than a hundred yards presents a uniform thickness of 2 feet. It is however a rather poor one, though not poorer than is often worked. Upon this ore rests a seam (about 2 feet) of very fine grained homogeneous slate, having a smooth and regular cleavage adapting it either for roofing or writing slates. Eight miles above this, at the falls of the river, this seam, or rather its representative, is exposed, sometimes consisting of 2 bands, each about a foot in thickness, sometimes divided into 3 or 4 thin seams. Frequent alternations of character are thus presented in the coal seams as traced from point to point, a band of slate usurping the place of coal, and being again replaced by that material. This seam has not been found on the river between the two last mentioned localities, but it must occur a short distance inland, as the calcareous rock underlying it is met with at several points on the river intervening between these localities, clearly indicating the existence of the coal in the hills a little removed from the river, though along its margin no exposures are to be seen.

The *lower* seam was opened several years ago on the estate of Mr. Cunningham, a short distance north of the turnpike, but the caving in of the superincumbent shales prevented any examinations at this point. The seam is said to yield from two to three feet of coal of good quality.

Eight or ten feet beneath the coal is a band of impure *limestone* two or three feet thick, included in calcareous, argillaceous slates, and occasionally containing nodules of iron ore. This rock has been used for lime.

About three miles below the turnpike on Stoney river the sandstones and slates, identified as those overlying the lower seam, are exposed for a short distance, at first horizontally, and afterwards assuming a SE. dip. These slates are beautifully fossiliferous, abounding in ferns and other vegetable impressions, and moreover contain two bands of very *rich iron ore*, the upper varying from one to six inches, the lower from two to three.

Higher up the hill the peculiar calcareous rocks, elsewhere seen to separate the upper or second seam from the lower, are slightly exposed, consisting in part of a quite pure limestone. The upper seam may therefore be expected at a greater altitude in the hill not far above the limestone.

Four miles above the turnpike the *lower seam* is again exposed, sometimes divided into two, each about a foot in thickness, the separating material being a thin seam of slate. In other places the intervening slate expands to a thickness of two or three feet, and thin bands of the same material appear in the upper and lower portions of the seam dividing them into five or six thin layers.

The *limestone* underlying the coal occurs just at the river's edge, exposed to the depth of three or four feet, which is probably its full thickness. It is of a dark blue colour and fine grain, more argillaceous above than below, and containing nodules of pure iron ore near the bottom.

This seam also shews itself at the falls of the river 7 miles above the turnpike, consisting here of several thin bands, only the upper one of which crops out from beneath the bed of the river. It is about one foot in thickness, of good quality, but disposed to crumble. Of course the underlying limestone is not exposed, the coal being the lowest stratum in view, but it must occur not far inland, as the dip of the rocks would there cause it to crop out. Above the coal, and separating it from the calcareous rock hereafter to be mentioned, are shales and shaly sandstones, in the lower part of which, and immediately over the coal, is a rich band of *iron ore* four inches thick.

Limestone between the First and Second Seams.

Wherever in this basin a sufficient depth of exposure was met with, a calcareous band of rocks was found to intervene between the upper and lower coal. All the members of this band are of a light lead colour, and are usually calcareous, though assuming the characters of shales and sandstones, and occasionally of *quite pure limestones*, and generally including one or more seams of *iron ore*. This band is seen imperfectly exposed on Stoney river about three miles below the turnpike, but the presence of iron ore in it could not be satisfactorily ascertained, from the obscured condition of the strata. Four miles above the turnpike it is again exposed on the river, overlying the

lower coal, and separated from it by 15 or 20 feet of shales and sandstones. It here abounds in a *rich iron* ore, occurring in nodules sometimes eight and ten inches in diameter, fine grained, homogeneous, and of a delicate lead colour. Besides this variety, it also contains another and coarser kind, quite siliceous, and having the aspect of a poor ore when freshly fractured, but upon exposure assuming a deep ferruginous hue. This is irregularly distributed in the shales.

At the falls of Stoney river the same band is again exposed, with a thickness of from 15 to 20 feet, in the upper part siliceous, in the lower shaly. Here the coarser variety of ore predominates, and is found in great abundance. At the preceding localities the rocks in question shew themselves 30 or 40 feet above the water's edge, but five miles above the turnpike, owing to the rapid rise of the bed of the stream, they are exposed immediately above it, but too imperfectly to ascertain the extent of iron ore included in them.

At the falls of the river the calcareous band rests immediately upon the lower coal, whereas at other localities they are separated by more than 20 feet of other strata, so that it is impossible to give any rule of general application as regards its distance from the lower or the upper seam.

The importance of this band, due to the valuable layers of limestone and iron ore it contains, cannot fail to suggest to those interested in this region, the advantages that may be derived from an examination of its contents wherever it may be exposed. Nor should it be forgotten that the limestones of this band, as well as the similar rock occurring beneath the lower seam, are of sufficient purity to be made subservient to the agricultural improvement of the neighbouring country.

It may be added, that at some points the micaceous slabby sandstones have a cleavage that admirably adapts them for flagging and similar purposes.

WESTERN BASIN.

The coal measures of this basin extend high up on the western flank of the ridge, separating Stoney river and Difficult creek, and there expose a coal seam, which, by comparing the associated rocks, has been identified with the *upper of the two seams* described as occurring in the last basin. No openings, however, have been made on the Virginia side of the basin. Judging from the outcrop of this seam it includes about two feet of good and one of impure coal. As might be inferred from its lying near the western margin of the basin, its dip and that of the enclosing rocks is to NW. Still lower down the hill, and geologically underneath the upper seam, the calcareous band is exposed, associated with iron ore, which appears by infiltration to have been converted into per-oxide.

The lower seam shews itself in the bed of Difficult creek, a short distance above the turnpike, presenting a thickness of about one foot. On the eastern side of a bold hill, interposed between Abraham's creek and the N. branch, we meet with the calcareous band, and at

a higher level the overlying coal seam. Above the coal, and forming the upper part of the hill, is a considerable thickness of olive drab shales, which are well exposed on the turnpike, but give no indications of either iron or coal. Just to the east of the North branch these shales are seen to change their dip from NW. to SE., indicating the position of the centre of the basin. It is extremely improbable that any other than the two seams already mentioned, have been retained in this position of the basin on the Virginia side, but in Maryland, ascending the bold flank of the Backbone from the North branch, one, and probably two, higher seams occur. Not having been opened their thickness is unknown, but should future explorations prove them valuable, it would be advisable to search for them further south on the Virginia side, where, possibly, through the less denuded state of the surface, they might be found high up in the hills.

CHAP. 3.

Basins of Preston and Monongalia Counties—Mount Carmel Basin and Briery Axis.

The Backbone of Alleghany, west of the last of the three minor basins above described, is a broad anticlinal axis, flanked and for the most part capped by formation XII. Of course, therefore, while the conglomerate of its eastern slope is seen dipping gently towards the SE. so as to underlie the coal measures of the basins immediately east of it, that of its western side presents the contrary inclination. But owing to the short interval between these gentle western dips, and the recurrence still farther to the west of eastern ones, the beds of formation XII. forming the shallow trough across which the Northwestern turnpike passes, are either at or very near the surface, and thus in this region no coal rocks are seen in the interval between the Backbone axis and that lying next west of it.

This shallow basin, however, expands and deepens as it extends in a northwesterly direction through the adjoining parts of Maryland, and when traced into Pennsylvania is found to be identical with that described by my brother, prof. H. D. Rogers, as included between the axes of the Alleghany and Negro mountains.

The wide region of broken and lofty hills, very erroneously traced on the map under the name of Briery mountain, where traversed by the Cheat river, displays the underlying Appalachian rocks forming a broad anticlinal axis, comprising the formation from IX. to XI. inclusive, the eastern slope of which forms the western side of the basin here referred to, while the western slope extending nearly to the Cheat river, directly east of Kingwood, becomes the eastern margin of another basin, in the midst of which that town is situated.

Of the eastern and western limits of this broad tract, occupied by the lower formations, and in which, therefore, the coal measures are no where to be found, the several subjoined details will enable the reader to form a correct opinion.

At Mount Carmel and along the valley of Rhine creek formation XII. has been swept away, leaving the underlying rocks of XI. exposed. At Mr. Schaeffer's in this valley, about one mile to the south of German Settlement, the limestone (XI.) of the eastern side of this basin is displayed to the depth of from 20 to 30 feet. The rock is of a dark greenish grey colour and quite fœtid, yielding an impure though workable lime. No traces of it are to be met with on the turnpike.

The centre of this basin passes through Mount Carmel, where the limestone is exposed. The upper beds of the same rock are also seen a short distance to the SW. of the village on the cross road leading to the Kingwood road. It is here underlaid by a sandy limestone, adjoining which the upper bed is impure, though still higher it is of great purity. Near this the *upper* part of the *lower limestone* is seen, consisting of rock of very good quality. One mile to the SW. of Mount Carmel the *lower* part of the *lower limestone* displays itself of a delicate greenish drab colour, and one fourth of a mile still more towards the west, as we approach the mouth of Salt Lick, we pass out of the limestone and enter the next formation (X.), west of which we come upon IX. which continues to the mouth of Salt Lick.

In the vicinity of German Settlement, on the summit of a high hill on the northern side of Rhine, is the outcrop of a body of *iron ore* of superior quality. It occurs on the surface over a wide area in large fragments, and is also found a short distance beneath. These fragments are evidently in place, and are portions of a bed which occurs near the surface, in the upper part of formation XI.

The conglomerate of the *western* side of the basin is seen ¾ mile to the east of where the road crosses Snowy creek. It is here very irregular in its line of outcrop, owing to great inequality of denudation, and forms a low hill which both to the north and south of the road rises to a much greater elevation. This high ground terminates to the north of the valley of Rhine creek, where the underlying rocks are exposed.

The lowest formation seen in the Briery axis, south of the Piney swamp country, is IX. On the Uniontown road leading through Mount Vernon, the conglomerate of the eastern side of this axis appears not far to the west of Herndon creek, and its line of outcrop which is here quite irregular, is for 3 or 4 miles nearly coincident with the state line, encroaching a little on the Virginia side.

This axis is denuded into irregular lines of hills, all of which attain a nearly equal height, viz: about 1600 feet above the level of the Cheat river opposite Kingwood.

The *limestone* of XI. of the *western* side of this axis is exposed half a mile west of the Uniontown road, on the estate of Mr. Christian Smith, in the valley of Roaring creek. At this place only about 8 or 10 feet of it are seen, consisting of fine grained dark and light grey limestones of excellent quality.

Where the axis is crossed by the Uniontown road, formation X. is not met with in mass, but fragments of its olive coloured conglomerate bestrew the surface. On the Kingwood road, however, formation X. of the *eastern side of the axis* comes in view a short distance west of

Snowy creek, presenting of course a southeastern dip. On the creek, and therefore east of X., the limestone of XI. makes its appearance.

On the *western* side of the axis the *limestone* is exposed at many places south of the Kingwood road, and both its *upper* and *lower* divisions are seen about 4 miles from the road in the same direction. The *former* consists near the top of a fine grained dark bluish grey limestone, in the middle of a similar rock having a light grey colour, and at bottom of a dull bluish rock less pure than either of the preceding. The *latter* is of a light grey colour and very pure, and judging by the fragments seen around, is underlaid by the usual bed of sandy limestone. Both the upper and lower limestones are frequently exposed between this and where the Cheat passes through the axis, and along this deep trench in the mountain it displays itself in a bold escarpment.

At Everlie's mill on Muddy creek, the limestone of the western side of the axis is met with of a deep blue above and a light grey below, and throughout homogeneous and rich. It here rests upon a red sandy limestone or calcareous sandstone. The Pine swamp region is made up of the rocks of formation XI., the limestone generally at the surface. The most eastern exposure of the limestone of the western side of the axis is on or very near the state line. About half a mile east of this line formation X. comes in view.

The limestone of the eastern side of the axis is extensively exposed on the Youghioganey at the mouth of Hoy's run in Maryland. It is of a deep blue colour, impure and slaty, and highly fossiliferous.

Opposite Kingwood the western boundary of the conglomerate is 2 miles east of Cheat river. Farther north the eastern boundary of the conglomerate is 1½ mile east of where the road crosses Roaring creek.

This axis is cut through by the Youghioganey, which leaves it not far above the mouth of Bear creek. To the north of this, the main central ridge of the axis is known as Negro mountain, and the western ridge, which is the continuation of the Briery mountain of Virginia, is called Winding ridge. This ridge is capped by the conglomerate of XII., the western boundary of which is 1½ mile to the east of Petersburg.

To the *south* of where Cheat river leaves this axis, it is divided into two bold ridges; the *eastern* one, that which you descend in going from Mount Carmel to the river, is known as *Cheat* mountain. No. X. is exposed near its summit, 3 miles southwest of Mount Carmel.

It is impossible to define the western boundary of the conglomerate on the summit of this mountain, as there is a wide area to the west of Mount Carmel, without exposure, being a flat country, the soil of which is rich in the pebbles of the conglomerate of XII., leaving no doubt of that formation being almost immediately beneath the surface and in a horizontal position. In the centre of the axis, which is at Hooton's, the rocks of IX. are thin and large, and interstratified with olive shales like those of No. VIII.

The ridge made up of the *western* side of the axis is known as Laurel mountain. The *eastern* boundary of the conglomerate dipping W., flanking and capping it, is 2½ miles W. of the mouth of Big Buffaloe.

The limestone of XI. is slightly exposed on the eastern flank of this mountain, 2 miles W. of the mouth of Big Buffaloe. It is argillaceous, and of a dingy grey colour, but burns into a workable lime.

CHAP. 4.

Kingwood Basin and Kingwood Axis, the same as the Laurel Hill Axis of Pennsylvania.

West of the Briery axis, just described, there occurs a narrow though important basin, including coal seams and other valuable deposits, whose boundary on the west is formed by a low and gentle axis, the continuation of that described by professor H. D. Rogers as the Laurel Hill. On looking at the map, it will be perceived that after crossing the Cheat river, the Briery mountain is represented as pursuing a NE. course for about 10 miles, and then taking a direction due north to the head of Little Sandy creek in Preston county, after which it again resumes its northeastern bearing, passing into Pennsylvania, where, some distance north of Smithfield, it is known as Laurel Hill. By the delineation thus presented, the false impression is likely to be made that the whole of this winding tract of highlands constitutes in reality one range or axis, while in fact it comprises two. The eastern or Briery axis has already been described as following the direction indicated on the map, from the Cheat river to Pine swamp, passing through and a little west of the latter tract in the prolongation of the same northeastern line, and following the direction of the Youghioganey towards Selby's Port, so as to pass a little east of Smithfield on the National road in Pennsylvania, a few miles north of the state line. Throughout much of this tract, the denuding agencies have cut down this elevated region into a series of hills or knobs, so as to present but little indications in the topography of the regular course of the axis here referred to.

The western axis, of which on the map a small portion is delineated near the NE. corner of Preston county, is in reality continued in a southwesterly direction a little west of Kingwood, and forms, as already stated, the western boundary of the basin of which I am about to treat. The ridge delineated as connecting the two axes, in a north and south direction, a little west of the Preston line, is in fact a *part of this basin*, occupied by comparatively high ground, and comprising the coal measures intervening between the two axes just described. I have been thus particular in correcting the erroneous impressions likely to be produced by an inspection of the map, from a wish to convey to the reader a clear conception of the region in the present instance so falsely indicated by the topography laid down on our map, and from a conviction that accurate knowledge of this description furnishes the only guide to sure and successful research.

The following data will serve to indicate the course and boundaries of this basin, as well as to illustrate the nature and extent of the valuable materials which it includes :

North of Kingwood, the conglomerate of XII. is but slightly exposed on the summit of this western ridge, (Kingwood axis,) and is rarely seen in place over an extensive area. On the Brandonville and Selby's Port road, 6 miles from the latter and 2 miles east of the junction of this and the Crab Orchard road, (*vide* map,) it is seen in tabular masses, but does not here form a distinct ridge, the coal rocks rising to an equal elevation. It may thence be traced through a point 1½ mile west of Muddy creek on the Brandonville road, and across the Cheat a short distance above the mouth of Laurel run.

The limestone of formation XI., underlying the conglomerate of the eastern side of this axis, rises above the water's edge on the Cheat, about ½ mile below the mouth of Laurel run, and continues in view for about half a mile. Including the interstratified argillaceous shales, it is here about 80 feet thick, the upper 50 or 60 of which consists of a deep blue and bluish grey rock, highly bituminous and fossiliferous, and largely interstratified with soft argillaceous shales, and sometimes, though rarely, with pinkish calcareous bands. The lower 15 or 20 feet include light grey and bluish fine grained limestones, very rich in lime, frequently displaying the oolitic structure. Associated with these lower bands, we find layers of a dark lead colour, presenting a strong ferruginous stain where weathered. This variety, as will hereafter be seen, yields a good *hydraulic lime.*

About ¾ of a mile below the mouth of Laurel run, the limestone ceases to be exposed, and we meet with fragments of coarse sandstone strewed profusely over the surface, belonging to formation X.

The limestone of the *western* side of this axis is exposed on Cheat river, ⅝ths of a mile above the mouth of upper Bee run, and though badly displayed, evidently exists in a large body. Much of it is of excellent quality, and yields a superior lime. Overlying the limestone is a massive sandstone, slightly calcareous, and varying in colour from a dingy white to grey, fine grained and homogeneous, 15 or 20 feet thick. The red slates and sandstones of the upper part of XI. are also here slightly exposed, and contain iron ore of superior richness, though apparently in thin seams.

Two miles west of Kingwood, the conglomerate shews itself over a width of about ¼ mile, though even within that area its depressions are occasionally filled with the shales of the coal measures. It does not occur on the summit of the ridge, but rather towards its eastern side.

As it extends in a southwesterly direction, this axis opens out and at some undetermined point between this and the NW. turnpike, brings formation XI. into view. Where intersected by the turnpike, it forms the two ridges crossed in going from Evansville to the Tygart's Valley river. The most eastern of these ridges, known as the Three Fork Hill, presents the conglomerate on its eastern side, passing out of view with a gentle southeast dip. This occurs ⅜ths mile west of where the turnpike crosses Three Fork creek. The western of the two ridges, called Fort hill, is flanked towards its western base by the same rock, here of course inclining to NW. This is seen 2 miles west of Tygart's Valley river.

The valley between these ridges is made up of the upper rocks of formation XI., but they are not sufficiently developed to expose the limestone.

At Kingwood the basin is 6 miles in width, but in the neighbourhood of Evansville it is much wider. At the same time, however, its depth does not appear to be increased, and hence unless some important change in this particular should occur as it extends still further south, there is no reason to anticipate the existence of any higher seams of coal in that direction, than in the part of the basin lying between Kingwood and the turnpike.

As far as this basin has yet been examined, it contains but *three seams of coal*, the two upper ones alone being worked. Of the *lowest seam* but little is known. It is said to be in view in the bed of Cheat river at very low water, half a mile below the Kingwood ferry, and was slightly exposed a few years ago by a slip at Snyder's mill, on this river, resting as is affirmed upon a limestone. It has been worked only at one locality, but the opening is now concealed. This seam, on account of its low position, will only be accessible where the Cheat river cuts through the centre of the basin. Where formerly opened, at the point alluded to above, one mile below the Kingwood ferry, the shales which overly it contain *five bands of rich iron ore* within the space of four or five feet, the lowest band occasionally four or five inches thick, the upper ones generally about two inches.

The *middle seam* generally yields from two to three feet of coal which is valued for fuel, but rather too sulphureous for the forge. Being more conveniently placed than the upper seam, and being exposed on both the eastern and western sides of the basin, it is very generally mined.

The *upper seam*, wherever met with, is found low down on the flanks of the hills. Besides a general examination of this seam in different parts of the basin, particular attention was given to its exploration, and that of its associated strata, as displayed on the flanks of the hills bounding the Cheat, where peculiar facilities existed in aid of our investigations. Where this seam has been explored by colonel Fairfax at several localities, south of the Kingwood ferry, it varies from two and a half to three feet in thickness, and is overlaid by about a foot of slaty coal. Beneath it is a calcareous rock, the upper two feet of which is shaley, but the lower four or five, compact and tolerably pure *limestone*. The shales overlying the coal abound in nodules of a very *rich iron ore* of a delicate grey colour.

The same seam has been opened at various places near the river, but owing to the circumstance that the mining is performed in the winter only, the workings, when visited, were not in a state admitting of satisfactory examination. Where worked on the west side of the river, a quarter of a mile south of Kingwood by Mr. Price, the seam is two feet six inches thick, not as usual covered by a layer of slaty coal. It is quite sulphureous, of a compact texture below, but inclined to crumble towards the top. The *iron ore* found in the overlying shales on the opposite side of the river is here replaced by nodules of impure limestone.

grey, fine grained sandstones, very obliquely stratified, internally of a light grey colour, slightly calcareous, 20 or 30 feet thick. Overlying these a fine grained limestone is slightly exposed. These rocks have a very slight inclination to the NW.

This axis is exposed on the Morgantown and Kingwood road five and three quarter miles from the latter, which makes the eastern basin about three and three quarter miles in width; the original basin is therefore about equally divided by this axis, the general width of each being about four miles.

The coal of this seam is generally of a better quality than that of either of the lower ones, but as will be seen by the following descriptions, is very variable in thickness. At Mr. Beatty's, 3 miles south of the mouth of Buffalo creek, it measures about 4 feet, including 8 or 10 inches of impure slaty coal. It is very compact, of a dull lustre, and striated structure, with its fracture perpendicular to the Striæ, and breaks with difficulty. It is much approved by the blacksmiths. One fourth of a mile south of this, where opened on the estate of Mr. Wolf, its quality is the same, but its thickness is reduced to about 3 feet.

Two miles SSW. of the mouth of Buffalo creek, on the estate of colonel Fairfax, the seam is divided by a band of slate 6 or 8 inches in thickness, inclusive of which it has a total width of 5 feet. At Mr. Murrell's, on the head of Deep Hollow run, it has dwindled to a width of 18 or 20 inches, and near Snyder's mill it measures about the same. At the former locality the overlying shales are very rich in fossils in a fine state of preservation.

On the western side of the basin opposite Kingwood this seam is much thicker. On the estate of Mr. Higgins it measures 7 or 8 feet, including the interpolated shales, and yields about 5 feet of coal, 3 of which is in one uninterrupted stratum. Corresponding to this increase of thickness, there is an improvement in the character of the coal. But the expansion here described is quite local.

Limestone of the Kingwood Basin.

The coal measures of this basin contain 3 bands of limestone. The *lower band*, underlying the lowest coal seam, is exposed *but once* in the bottom of the river near Snyder's mill. Its character and thickness are as yet, therefore, matters of conjecture.

The *middle band* underlies the middle coal seam, and has been already alluded to in the description of that seam. It often attains a thickness of 4 or 5 feet, and from its purity and frequent exposure, is to be esteemed a valuable resource in connection with the agricultural improvement of this region, as well as for other uses to which it may be applied. Should its powers as a hydraulic cement correspond with external indications, and the results of the trials I am now making, it will acquire a new claim to the attention of those interested in its development. The average thickness of the bed, as examined at a great many places, is about 4 feet. It is usually of a light grey or delicate lead colour, fine grain, homogeneous, and possessing a very

smooth fracture. Though often largely impregnated with iron, it is probably never so much so as to be unfit for masonry, to which it has been frequently applied with satisfactory results.

The most southern exposure of this axis is on the road from Kingwood to Smithfield in Monongalia county, 4¾ miles from the former place, where it developes quite a prominent ridge. On this high ground, the coal rocks are very irregularly denuded, and in some places occur on the summit of the ridge, though the conglomerate is there generally exposed. At this point, the eastern of these two coal basins is not more than 2 miles in width.

But little is known of the coal seams south of the commencement of this axis, as our examinations have as yet been confined to the neighbourhood of Brandonville. At this place there occur three seams of coal, which we succeeded in identifying with those of the Kingwood basin. The lowest of these, as in the Kingwood basin, is too low to be generally accessible. It was exposed in the bed of Sandy in making the examinations necessary for sinking the sills of the bridge, but nothing could be learned respecting its thickness.

The *middle seam* is most generally worked, though usually thinner than the one above. Where opened near the bridge over Big Sandy it is said to be 4 feet thick. The coal is quite sulphureous and overlaid by a highly carbonaceous slate. It is also quite variable in thickness, as will appear from the fact, that on the estate of Mr. Rhodoheaver, one mile east of Brandonville, it measures only 2 feet 9 inches. Though worked in numerous places in the neighbourhood of Brandonville, the condition of the openings which are in use only in the winter, made it impossible to examine the seam, excepting at a few points.

The *upper seam* worked at a higher level on the hills, is superior to that of the middle seam, but its thickness and local characters remain for future investigation.

Limestone.—Between the middle and upper coal seams is a band of limestone about 4 feet thick. It is of a dark bluish grey colour, fine grain, smooth fracture, and like most of the limestones of the coal measures, slightly ferruginous. This band has been quarried near the Sandy bridge, and is seen on the estate of Mr. Rhodoheaver, one mile east of Brandonville.

One and a half mile above the bridge on Big Sandy is a bed of coarse iron ore which appeared to be upwards of a foot in thickness, and a similar ore is associated with the limestone.

Whether these *three coal seams* are contained in the basin after the development of the axis, is yet to be determined. That portion of the basin lying north of Cheat river was examined as minutely as the scarcity of openings would permit. From the imperfect data yet collected, it would appear probable that the upper of the three seams is met with in this portion of the basin. As occurring on Mr. Seaport's land, it measures 4 feet, and presents at some depth beneath, a fine grained, homogeneous, argillaceous and siliceous slate, much approved of as an oil stone.

A limestone of good quality occurs in this basin, but its position in relation to the coal seams has not yet been determined. On the estate

of Mr. Walls this band is about 4 feet thick, it is also slightly exposed on the estate of Mr. Gribblo. In the Monongalia Glades, if report be true, the coal seams above noticed must be developed in much greater thickness than usual, but on this subject future observations can alone enable me to decide.

CHAP. 6.

Laurel Hill Axis—Its Limestone and Iron Ores.

The broad elevated tract extending from Pennsylvania into Preston and Monongalia counties, in a direction nearly coinciding with their common boundary, and which is described on our map under the name of Laurel Hill, contains another and the last important axis met with in this part of Virginia. As followed in a southwesterly direction, the dips of the rocks on both sides of the ridge are seen rapidly becoming less, and the axis thus flattening out soon buries from our view the Appalachian strata previously exposed, while the ridge itself subsiding to a less and less elevation, is at length entirely lost in the general level of the country. Beyond this point, which is near the head of Field's creek, a tributary of Three Fork, there is in reality no mountain such as delineated on our map, but an undulating region scarcely to be distinguished from the adjoining tracts on either side, and all that remains of the orginally conspicuous axis is merely a gentle roll or broad wrinkle in the coal measures, of too little force even to bring the conglomerate of formation XII. into view. Hence more correct conceptions of the topographical as well as geological features of this tract would be imparted were all that portion of the Laurel Hill laid down as extending south of the head waters of Field's creek obliterated from the map.

The few details annexed will serve to shew the position of the eastern margin of the great coal region extending from the western flank of this mountain across the valley of the Monongahela, but much farther exploration must yet be devoted to this region, before I shall feel prepared to enter into a minute description of its structure and contents. The value of the ores and limestones associated with formation XI. and with the lower coal rocks of the Laurel Hill axis, will be illustrated sufficiently for the present, by the accompanying descriptions of them, as seen at several important localities, as well as by the details of their composition comprised in the chemical division of the report.

The *upper limestone* of XI. forming the eastern side of this axis, first rises above the surface near the junction of Lower Bee run with the Cheat where it is boldly exposed. So much of this limestone as is here in view, amounting to about 20 feet, is seen to consist of rocks generally of a fine grain, smooth fracture, and dark grey colour, though sometimes bluish black.

Between the upper and lower limestone are about 30 feet of sandstone of a light grey colour, less calcareous than that which usually underlies the limestone, and wanting its diagonal markings. Beneath

this sandstone is about 4 feet of limestone of a light grey colour, having much the same aspect as the overlying sandstone. Beneath this is about 4 feet of a less calcareous rock, of a light grey colour, largely impregnated with iron. Beneath this we encounter the gritty or sandy limestone with the characteristic markings running obliquely between the surfaces of stratification.

The limestone of the *eastern* side of this axis is again slightly exposed at the quarry of the Greenville furnace, in a gorge of the mountain near the state line. These are the only exposures of this rock as appertaining to the eastern side of the axis, north of the Cheat river.

The conglomerate (formation XII.) of the *eastern* side of this axis shews itself about ¾ mile to the west of the county line, where it is crossed by Laurel run. It is well exposed in the lateral gorges of the mountain, where it is seen stretching at a gentle angle from the base to the summit. It generally covers an area from ¾ to 1 mile in width.

On the summit of the mountain is a narrow denuded valley, composed of the upper part of XI. The denudation is not here deep enough to expose the red shales and sandstones of this formation, the only rocks laid bare being the black slates which immediately underlie XII. It is among these shales that the ores supplying the Henry Clay and Greenville furnaces are found. These ores occur in three different bands, which are in general included in a section of 20 and always within 30 feet.

The *upper or castile vein*, the most uniform in thickness, varies from 8 to 15 inches, and having but a slight covering of shale, has been less protected than the lower bands from atmospheric agencies. It is therefore usually found in a decomposed state, the whole bed sometimes presenting the condition of a friable shaly oxide, much valued on account of the ease with which it works. Occasionally it occurs in nodules merely encrusted with the oxide, the nucleus being in the original state of proto-carbonate.

Beneath this, 8 or 10 feet, we meet with the *middle or rock vein*, generally 8 or 10 inches thick, though varying from 4 inches to 3 feet. This is for the most part compact and undecomposed, more uniform in character than the other veins, and in general rich and fine grained.

Below this, at a depth of about 8 or 10 feet is the *lower vein*, varying from 2 inches to 6, and averaging 4 inches. This is usually coarse and siliceous, and chiefly valuable at the outcrop, where it has been decomposed. All these ores contain vegetable impressions.

On the Kingwood and Morgantown road, 9½ miles from the former place, the conglomerate of the *eastern side* of this axis is exposed. The Laurel Hill is here not more than 1 or 1½ mile in breadth, and on its summit irregularly denuded into small vallies, the hills being capped by the conglomerate in large masses, and the top of XI. slightly exposed in some of the vallies.

The conglomerate of the *western side* of this axis crosses Cheat river not far to the west of Quarry run, and continued southwesterly, shews itself on Decker's creek at the mill, passing at a very short distance to the east of Clear's furnace. The limestone (XI) of the western side of this axis rises above the surface ¼ mile east of the mouth of

Quarry run, and displays itself boldly at the mouth of Scott's run. It is also exposed on Decker's creek, one mile above where the stream leaves the conglomerate. The lower 6 or 8 feet is of a light grey colour and very pure; above this, as far as in view, it is impure and slaty. Still higher up on the creek, the limestone of the *eastern* side of the axis is extensively exposed.

Iron Ores on Decker's Creek.—The ores met with above the conglomerate on the western slope of Laurel Hill, and of which use is made at Mr. Clear's furnace on Decker's creek, may be considered as occupying two general geological positions, and will be treated of as the lower and upper groups of ores.

Lower Group of Ores.—In the lower part of the shales underlying the lowest coal seam, two bands of iron ore occur, each about a foot in thickness, and separated by about four feet of shales. This ore from its slight protection is generally in a decomposed state, consisting chiefly of per-oxide of a loose shaly texture, and therefore the more easily worked, along with which a nodule of the original carbonate is occasionally found. Beneath the lowest of these two beds of ore is a white sandstone, 4 or 5 feet in thickness, and beneath this is a third bed of ore, generally 6 or 8 inches thick, which, having been defended by the overlying strata, has escaped decomposition, and displays its original character of a compact proto-carbonate. A few inches below this in the shales, a fourth band occurs, 4 inches in thickness. Below this, separated by shales of unknown thickness, probably not more than 3 or 4 feet, occurs a band of limestone 5 feet thick, portions of which are quite rich, but the principal mass impure. From this stratum is procured the flux used at the neighbouring furnace. This group of ores occurs very extensively on the western side of Laurel Hill, where, owing to the gentle dip of the strata, being at about the same angle as the slope of the surface, these bands present themselves over a wide area on the western flank of the ridge, where they have been traced for many miles. As would be expected, owing to infiltrations from above, the ore at the bottom of the hill is generally richest.

Upper Group of Ores.—These ores occur much higher in the series, being above the second seam of coal. They rest upon a lead coloured siliceous and argillaceous sandstone, and are overlaid by siliceous slates of the same colour, which being the first rocks of this kind met with above the second seam of coal, may serve as a landmark in searching for the ore. This ore is very variable in thickness, usually occurring in large nodules, sometimes fine grained, though generally coarse and siliceous, occasionally so much so as to resemble a coarse sandstone rather than iron ore. Indeed it frequently gives no indication of the presence of iron until after burning or long exposure. Like the ores of the lower group, it is explored over a wide area, being found within a short distance of the surface from the base of the hills to their summits.

SECTION VI.

OPERATIONS OF THE SURVEY IN THE REGION WEST OF THE GREENBRIER RIVER AND IN THE VALLEY OF THE KANAWHA.

CHAP. 1.

Rocks inferior to the Coal Measures in Meadow Mountain, Little Sewell, &c.

Under a former head a general account was given of the extent and position of the limestones, shales and sandstones of formation XI., as they are widely developed along the eastern margin of the coal region in Pocahontas, Greenbrier, Monroe and Mercer counties.

In no part of the state are the effects of denuding agencies more strikingly evinced than in the district here referred to. The wide tract occupied by formation XI., instead of presenting along its western boundary, a regular escarpment composed at top of the conglomerates and sandstones of XII. is here intersected by deep and long valleys connected with the waters of Greenbrier and New rivers, between which arise lofty knobs and broad ridges, crowned by the conglomerate at their highest points, and which, encroaching upon the intervening vallies as we trace them towards the southwest, coalesce to form the Great Flat Top mountain south of the New river.

The Little Sewell, Meadow mountain and Keeny's Knobs, are composed for the greater part of their height of the shales and sandstones of XI., containing near their upper boundary a thin band of siliceous limestone, and capped, as already mentioned, by the conglomerate. All these rocks, with some undulations, display a prevailing gentle dip to NW., and underlie the strata of the Big Sewell mountain. The latter consisting of shales and sandstones, differing from those of formation XI., and containing several important coal seams, appears to owe its peculiar characters to a remarkable expansion of the strata of XII., here including, besides the usual conglomeritic beds, numerous strata of slates, shales and sandstones, the latter often of a pinkish colour. As before remarked, additional investigations are required, especially in the vicinity of the New river, to ascertain the true extent and character of this intermediate formation, and for the present, therefore, no decided opinion can be given in regard to these particulars.

As an important preliminary to these farther enquiries, the altitudes of many of the principal knobs and ridges of this region have been ascertained by observations with the boiling point thermometer. Among these are the Big and Little Sewell, Meadow mountain, Keeny's Knobs, and the Blue Stone and White Oak mountains. By continuing these measurements, and connecting them with observations of the dip and character of the strata, I feel no doubt of being enabled clearly to elucidate every remaining obscurity in regard to the geology of this tract. The interesting question relating to the great expansion of the rocks underlying the coal of the Kanawha valley, acquires peculiar importance from the consideration that from these

strata there is every reason to believe are derived the saline ingredients which enrich the numerous salt wells of that enterprising and prosperous region.

CHAP. 2.

Sketch of the Coal Seams and other Strata along a part of the Kanawha Valley.

Not designing to enter into details with respect to the coal region lying west of this tract, and traversed by the Great Kanawha, in much of which our researches have not yet been completed, I shall merely present a few statements descriptive of the position and characters of the coal seams and their accompanying strata as developed in the lofty and liberally productive hills which bound the valley of the Kanawha between the falls and Charlestown.

It will be seen from these details that for a distance of nearly 30 miles, viz: from a point a few miles below the falls to Charlestown, all or several of the coal seams lying beneath the black flint rock formerly alluded to are to be met with in the slopes of the lofty hills on both sides of the river. So great a prolongation of exposures, displaying the same division of the coal series throughout, could not have existed but for the fortunate occurrence in this tract of two broad undulations or axes, retaining the strata above the level of the river, when by a continuance of the original northwestern dips as displayed in the neighbourhood of the falls, they would have been carried entirely out of view within one third of the distance along which they are now exposed. The first or most eastern of these undulations is seen to commence in the neighbourhood of Hughes's creek, the strata changing from their northwestern dip to the horizontal, and then rising as they extend westwardly, so as to present a southeasterly dip.

This dip continues to the hill between Keller's and Witcher's creeks, where it is succeeded by a gentle inclination to the northwest, which in a short distance is followed by a restoration of the southeasterly dip. The latter inclination continues to the Burning spring, gradually elevating the strata so as to carry the lower coal seams to some height up in the hills, after which the counter-dip to NW. reappears, and continues down the river to within about 10 miles of the Ohio.

The following details relating to a few localities will serve to convey a general idea of the positions and characters of the several coal seams and accompanying rocks as they are exposed to view along this magnificent natural section.

The numerous analogous details already collected, together with various researches yet incomplete in regard to the topography as well as the geology of this valley, will, it is hoped, hereafter enable me to present a full delineation of its structure in the accurate form of measured sections throughout its whole extent, while the chemical details relating to its salines now under examination, as well as those connected with its coals and limestones, of which a partial report will be

made in the sequel, will complete the interesting scientific labours devoted to the development of its resources.

The hills on each side of the Kanawha, in the neighbourhood of the falls, are made up of coarse sandstone and conglomerates at the base, with an alternation of yellow shales and slaty mecacious sandstones. Immediately in this vicinity no coal is to be seen, but in the more lofty dividing ridges, back from the river, it shows itself at various places, among which are the vicinity of Scrabble creek on the north, and Cotton and the other high hills on the south side of the river.

The conglomerate forming the lower strata for upwards of three miles down the river, disappears at the termination of that distance, giving place to the overlying micaceous sandstones. About five miles below the falls two coal seams make their appearance, but neither have at this point been worked. The upper of these is, however, more favourably exposed for working, and is accordingly opened near Mr. Huddleston's. It crops out a short distance up the creek about 120 feet above the base of the hill. It is a compact lustrous coal overlaid by a pretty heavy bed of blue shales, and resting on yellow shales, neither of which contains many fossil impressions. The lower seam, about 90 feet below this, is thinner, and the coal is not so good. The shales above it are extremely thin and fragmentary and full of indistinct impressions, principally ferns, &c. These hills were found to be about 700 feet in height, profusely strewed at their base with fragments of the black flinty rock found near their summits, and which will be described hereafter. Two or three miles farther down the river both of these coal seams, as well as the entire structure of the hills including them, are more favourably exposed at Smither's creek and Ryder's creek.

SMITHER'S CREEK.

The lowest coal seam is seen to crop out a short distance up the hill from the road side, just before reaching the creek, and has been partially opened. It is about three and a half or four feet thick, good coal, roofed by thin bluish shales and underlaid by yellowish shales. It is also worked about half a mile up the creek.

The next and most important seam is opened about 100 feet from the road up the hill, and is much thicker than the former: it is identical with the high seam found near Huddleston, is upwards of six feet in thickness, and includes three bands of black bituminous shales, the lowest of which is about twelve inches thick. The shales over the coal are compact and blue, remarkably free from vegetable impressions. Those below are yellow, and contain culmiferous and arundinaceous plants. Above this seam there are appearances of two other seams. Their tails are, however, extremely thin, and little attention has yet been bestowed upon them. About half a mile below the creek the main seam has been extensively worked by Mr. Stockton, and also below at Ryder's creek by Mr. Hervey. The following sections will furnish a knowledge of the structures and relations of these coal seams.

Section at Stockton's steam mill half mile below Smither's creek, commencing at the lowest stratum:

1. Grey Mica. shales and slaty sandstones.
2. Grey shales.
3. Limestone, compact bluish grey, fossil. stems, &c., two feet eight inches.
4. Yellow shales.
5. Narrow seam of coal.
6. Yellow micaceous sandstone.
7. Yellow shales, containing impressions of culmiferous and arundinaceous plants imbedded obliquely in the mass.
8. Fine clay, yellowish grey, extremely plastic and tenacious, two feet.
9. *Coal* seven feet, containing three seams of slate, lowermost one foot above the floor of the coal, about three inches thick.
10. Blue shales, containing but few impressions, and those of stems principally, and disseminated masses of argil. iron, &c.
11. Slaty shales and micaceous sandstones.
12. Coal shales, and traces of a very thin seam.
13. Moderately coarse grained sandstone.
14. Brownish shales and slaty sandstone.
15. Traces of coal.
16. Bluish calcareous shales, few impressions, shells, &c.
17. Black flint rock disposed in lamina from four to ten inches thick, seven feet thick.
18. Coarse grained yellow sandstone, below in heavy beds, above more slabby. This latter constitutes the capping of the hill. The general dip of the rocks is pretty uniformly to NW. about 2°.

RYDER'S CREEK.

A similar section, made at this point, presented precisely the same order of stratification, but in consequence of the dip carrying out of view some of the lower rocks, the lowest stratum here, on a level with the road, consists of the yellow sandstones, which immediately repose upon the narrow seam of coal below the principal seam.

The principal seam is by the dip brought lower down in the hills, and is opened at several points by Mr. Hervey. It agrees in structure with Stockton's seven foot seam, with the exception that the thickness of the lowest band of black slate is increased to about fifteen inches, so as to leave not more than five and a half feet of good workable coal.

The limestone which is referred to above as being low down in the order of formation, and which is well exposed near the steam mill, with its rounded and reddish weathered surface, should be regarded as one of the most important beds which has heretofore escaped attention. It is traced down the river for a short distance, when it sinks out of view, but probably again makes its appearance in the vicinity of or below Hughes's creek. Masses of it are seen in the bed of the creek, evidently derived from a stratum near at hand. The peculiar appear-

ance of the weathered surface of the rock, will always enable the observer to identify it. It is coated with a buff brown ferruginous oxide, giving it the aspect of iron ore. Of the hydraulic character of this and some of the other limestone bands of this region, some account will be given in the sequel.

The yellow shales which are found immediately below the heavy seam of coal and the upper portion of which presents all the characters of a good fire-clay, is the next remarkable formation in this region, not only on account of its value in the construction of furnaces, but also on account of the great number of impressions of culmiferous and arundinaceous plants which it contains, many of which are enclosed in an oblique direction in the stratum, so as to present a less flattened form than when they repose conformably in their bed. These shales contain also disseminated, flattened and kidney shaped masses of argillaceous iron ore, but not in sufficient abundance to render it valuable in an economical point of view.

Black Siliceous Rock, Flint or Hornstone.

This remarkable deposit which here appears of the thickness of seven feet, and at an elevation in the hills above the road at Ryder's creek of 466 feet, may be traced by its debris from near the falls, and seen capping the hills in broken masses at the head waters of Scrabble creek. It is found up the Gauley river on the NW. side, forming the tops of the hills, but cannot be traced in this direction above Twenty Mile creek. Thence it proceeds with a general gentle dip to the NW., and is found up all the creeks flowing into the Kanawha river. At Smither's, Ryder's and Hughes's creek it occupies a considerable elevation in the hills, being overlaid by a coarse sandstone, which, as low down as Keller's creek, is found to be a conglomerate. It is readily distinguished from all the associated strata by the resistance which it furnishes to disintegrating agency; and by its always presenting a regular bedding and a sharp angular structure. No fossils can be detected in it, but at Ryder's creek the blue shales upon which it reposes are observed to contain a few impressions of shells. Although throughout the structure of this rock is remarkably uniform, sometimes it assumes the character of a black siliceous shale, particularly in its lower portion. And above it is so dense and vitreous as to be readily mistaken for true flint, and properly entitled to the name of hornstone.

HUGHES'S CREEK.

Up this creek about ⅓ of a mile, and also on the main road, the principal seam of coal has been opened at the former point by Mr. Boasman, and at the latter by Mr. Childers. At both of these places it presents the same characteristic. Blue shales, compact, and but little fossil in the roof. Here, however, the included shales are thicker than at Stockton's, and the quantity of coal is in consequence diminished. The whole seam, including shales, is above 6 feet thick.

The bed of Hughes's creek contains masses of limestone, as before noticed, but no stratum of this rock has yet been found in place. At this point, as observed, a synclinal roll has occurred, which, about a mile further down the river, has brought up the lower seam, which is now mined by Mr. Morris Hansford.

This seam is about 3½ feet thick, is roofed by sandstone at one point, and a thin band of bluish shales at another. The coal is compact and lustrous, and the overlying shales very fossiliferous. Beneath the shales are yellow, and contain a few impressions. This is undoubtedly identical with the lowest seam observed on Smither's creek, which passes out of sight near Stockton's, and again rises near Hughes' creek. The sandstones above this seam are about 60 feet thick, and have reposing upon them a thick bed of yellow shales. Then follows the *main* seam of coal which has been only partially opened, but sufficiently to identify it with the Stockton seam.

Above these seams two others have been observed, before reaching the *black flint*, which here attains an elevation of at least 400 feet, and still preserves its thickness of 7 feet. It is here, as at Ryder's creek, overlaid by coarse grey micaceous sandstone.

The lower or 4 foot seam, as it is called, is opened in no less than 9 different points nearly opposite the mouth of Keller's creek, by the Messrs. Hansford. The direction in the line of dip is admirably marked out by the heavy bed of sandstone which overlies it, for here, as above, this seam has but a very thin roofing of shales. The continuity of the seam in this neighbourhood is interrupted by an abrupt roll attended with a slight dislocation, causing the sand stone to pitch suddenly down to the NW. at an angle of 5°, and cutting out the coal for the distance of more than ¼ of a mile above. Where this occurs, the seam is very much twisted, and portions of it included between the laminæ of the sandstone.

KELLER'S CREEK.

The same seam of coal which has been opened by Mr. Hansford on the opposite side of the river, appears here lower down on account of the dip, and is worked at two points by Mr. Fry. Here the shales over the coal are somewhat thicker, but much less impressed with fossil plants. Although the tails of the seams above this are to be seen by careful inspection, yet no opening has been made of any of them. It will be borne in mind that this seam and all the strata dip to the NW., i. e. down the river, and that as you proceed in that direction, all traces of them are soon lost, so that none but the higher, and here much thinner, seams are observed, one of which, the 4th, has been partially opened for domestic purposes. As you approach within a short distance of Witcher's creek, you observe a change to have occurred in the dip. This, though not discernible on the hill sides near the road, owing to the confusion of structure resulting from extensive slides, is readily remarked some distance back from the river, presenting a gentle roll which brings the 3d seam of coal into view a little above the road about half a mile east of the creek.

This seam has been partially opened by colonel Joel Shrewsbury, dipping at an angle of about $1\frac{1}{2}°$ to SE. It is about 3 feet in thickness, has resting upon it heavy beds of argillaceous shales, crowded with vegetable impressions. The shale is of a light grey drab colour, while the impressions are of a distinct brown. The tail of the next seam under this is noticed near the surface of the road a little below Witcher's creek, and it and the overlying seams dipping to the SE. make their appearance at different elevations in the hill side. This southeasterly dip continues to the vicinity of the Burning spring, where, as already described, the northwestern inclination is restored.

For a distance of several miles above and below Witcher's creek, the number of coal seams indicated by the outcrops on the hills is such as to prove a subdivision of the two or perhaps three lower seams by the interposition of thick bands of slate. Among the illustrations of the changeable character of the seams in this neighbourhood may be mentioned the almost entire replacement of the 2d seam by black argillaceous shales and the gradual reappearance of the coal, at first in thin wafery bands, afterwards expanding to a thickness of 3 feet, where opened for the use of Mr. J. Shrewsbury's furnace at the upper salt works. The important seam, hereafter to be described, as extensively exposed and wrought in the vicinity of Campbell's creek, much lower down the river, being actually observed to be divided as we trace it eastwards into two smaller bands by the interposition of a continually expanding bed of slate, would appear in the region now under consideration to be represented by at least two coal seams, which, followed still farther up the river, again gradually coalesce, forming at length the massive stratum already spoken of as Stockton's seam.

Of the precise nature of these interesting changes, and the number, position and character of the seams throughout this part of the valley, the accurate tracings and measurements of another season will, I trust, enable me to present a full and satisfactory account. The knowledge now acquired as to the less complex features of the adjoining districts, both above and below, while aiding the illustration of these curious peculiarities, will furnish essential assistance in the explorations yet to be made in the tracts remote from the river on either side, in some parts of which, especially on the Elk, a similar multiplication of coal seams has been found to occur.

Vineyard Hill included between George's and Campbell's Creek.

This hill extends in the direction of the river nearly north and south at this point, with but one interruption, where it is cut down by a narrow ravine called the Thoroughfare Hollow, leading to the creek which flows parallel with the river behind the lowest portion of the hill thus cut off. Above, between the Hollow and George's creek, it attains its greatest altitude, and when covered as it is now with herbage, appears to rise with a uniform but rapid slope to its summit. When, however, the trees are denuded of their foliage, it presents the peculiar aspect which belongs to all the hills bordering the Ka-

nawha from near the falls to the vicinity of Charleston, viz: a terraced or bench-like structure, generally found to indicate the position of the coal seams. Three such terraces are well marked on the side of Vineyard hill, and each of them presents us with a seam of coal and the accompanying shales.

Section of Vineyard Hill in the ascending order.

From the bed of the river to the bottom of the lowest coal seam is 54 feet. The four or five feet of the lowest portion of this height is made up of gravel and water worn pebbles of many of the older rocks which have been transported from the east. Among these are occasionally found not only the rocks of the Appalachian region, but also the chloritic, epidotic and granitic rocks of the Blue Ridge. Resting upon this, particularly in the vicinity of the salines, is a bed of yellow argillaceous and sandy clay used in the manufacture of brick, and reputed to be of good quality, and upon this reposes the vegetable mould which gives to the Kanawha bottoms their well known fertility. This, including the substratum clay, is from 20 to 25 feet thick.

Above this, and forming the immediate base of the hill, is a grey micaceous sandstone, composed of alternating layers of hard, compact and soft fissile rock.

No. 2. *Bituminous Coal*—the thickest and most important seam in the whole series. At Campbell's and George's creek this seam varies in thickness from 5 to 6½ feet. Immediately at the river, and a short distance up these creeks, it yields 6 feet of coal, including one band of black bituminous shale. It has been opened at several points by Mr. Lewis Ruffner, and in one place by Mr. William Shrewsbury—the seam in the latter instance being reached below the level of the road. Below Campbell's creek it sinks out of view, and the westerly dip of the strata continuing, it is not again brought up to the surface. It may be traced along George's and Campbell's creeks for several miles above their mouths, and is also well developed on the south side of the river, where it is worked by Messrs. Reynolds & Donally, and Noyes, Rand & Co.

The narrow seam of slate traversing it at Campbell's creek is seen to increase in thickness as it extends up the river, against the dip, so as to become as much as 8 or 10 inches at George's creek,—and continuing still to expand, it ultimately divides the seam so as to render it necessary to work the upper portions as independent seams.

The coal rests upon a slaty argillaceous sandstone, crowded with the broken fragments of coal plants strewed promiscuously through the mass, and for the most part lying in an inclined position. This stratum which is included in the measurement of that lying next beneath, varies at the place of the present section from 2 to 3 feet in thickness. The upper portion of the stratum has the character of a fire-clay.

No. 3. This stratum, which is about 40 feet in thickness, reposes upon the coal, and is composed for the most part of a *bluish drab coloured slaty shale*, including an occasional layer of slaty sandstone.

Where it is immediately in contact with the coal it is blue and highly bituminous. The slate resting directly upon the coal, include a thin seam of nodular iron ore in flattened ovoid masses, and presenting the concentric structure frequently observed to belong to this variety of ore. This is the heaviest bed of slate which occurs along the whole line of the Kanawha as far down as Charleston. The stratum of iron ore assumes in some places above this coal seam the appearance of a ferruginous conglomerate. This is particularly noticed to be the case on Campbell's creek behind the Thoroughfare hill. Indeed the whole of the shale at this point presents more of a ferruginous character than usual. A thin stratum of compact ore is found a few above the coal, and a similar ore below it in the bed of the creek.

Madreporite.—This curious fossil is included in the shale in large spheroidal masses, resembling the nodules or septaria of formation VIII. These masses are highly calcareous, constituting in fact a tolerably pure limestone, and generally found within a width of about 10 feet of the slate.

Although this section refers particularly to the stratification in the Campbell's creek series, it may be well to state here that a similar Madreporite deposite is noticed a few feet above the coal seam worked by Mr. Harvey 21 or 22 miles above, and again on Bell's creek. It should also be remarked that the shales which include it at these points contain disseminated masses of lenticular iron ore. Besides its interest in a purely geological point of view, this singular fossil is important as furnishing the means of determining the continuity of one of the most important coal seams in the series, viz: that at Stockton's steam mill and at Campbell's creek.

No. 4. *Bituminous Coal*—thin seam, not exceeding 20 inches, reposing immediately upon the shale above described, and found to be remarkably uniform in its occurrence. This seam has not been worked.

No. 5. *Argillaceous Sandstone*—slightly micaceous, light grey, sometimes bluish, disposed in regular lamina, in thickness from a few inches to several feet, which in some places include thin bands of slaty sandstone. This rock is extensively quarried for the construction of salt furnaces. It abounds throughout with fossil plants. Thickness 200 feet.

No. 6. *Bituminous Coal.*—This seam which will average about 3½ feet in thickness, is not opened immediately at this point, but is used extensively lower down the river by the salt-makers, where it is found pretty high up in the hills. Openings have been made in it by Messrs. Bream, Friend, Brooks and others on the north side of the river, and by Messrs. Patrick, Donelly, &c. on the south side. It is distinguished from all the others of the series by the prevailing character of the roof, which is a coarse grained brown and grey sandstone, sometimes disposed in pretty heavy beds, and sometimes slaty in its structure. This sandstone is about 215 feet in thickness, containing in some places, as in Mr. Brooks's drift, irregular nodular masses of compact argillaceous iron ore. This seam is rarely exposed in a distinct manner on the hills immediately facing the river, but in the ravines making up from the river, as for example, Bowman's hollow, is finely displayed.

The coal of this seam is not so black and lustrous as the Campbell's creek seam—it is more slaty, and the upper portion contains thin lamina of iron pyrites. It is, however, extensively mined from some distance on the river in the vicinity of Bowman's hollow. Like the other seams in this region, it reposes upon a dark coloured carbonaceous shale or slate, with oblique vegetable impressions. Great diversity is observed in the quality of this seam of coal at the different openings, even within short distances. Its thickness is also quite fluctuating. At some points, for example, in Bowman's hollow, 40 inches of good coal are obtained, while in the openings at Bridge hollow, lower down on the river, the seam is so reduced that not more than 28 inches can be procured.

No. 7. *Siliceous Sandstone*—generally coarse grained, but including a few bands of a finer texture. This rock, as before stated, reposes immediately upon a seam of coal generally without any intermediate slate. It occurs in beds varying in thickness from one to four feet, is less impressed by organic remains than the sandstone lower down in the series, and assuming the character of cliffs as you descend the river in a NW. direction, becomes lower and lower in the hills until it ultimately sinks below the bed of the river near to Charleston. Thickness 215 feet.

No. 8. *Bituminous Coal.*—This stratum of coal, which is the highest in this part of the series, has not been opened in Vineyard Hill or at any point above Mr. Daniel Ruffner's on the north side of the river, and Faurer's salt furnace on the south side. It is, however, always seen resting upon the last described sandstone, with a thin bed of intervening shales. It is generally easily found by tracing the overlying flint rock, beneath which it invariably occurs. This seam will average about four feet in thickness. The coal is rather inferior to that of the lower seam, being of a harder and more slaty structure, though presenting various degrees of purity at different localities. At Mr. Daniel Ruffner's a thin band of siliceous, slaty sandstone intervenes between the coal and flint rocks, but lower down this thins out and the roof is composed entirely of the flint, and so continues until its final disappearance under the bed of the river below Charleston.

No. 9. *Siliceous Rock, Blue or Black Flint.*—This singular deposit, which has already been described, comes next in order. On account of its definite character, it proves to be a valuable guide in tracing the accompanying formations, amid very considerable local undulations, enabling us to determine their true position and their dip. In the place of the section it is seen of its average thickness, a little exceeding 7 feet. The upper portions are nearly black, compact and vitreous in texture, and are properly deserving of the title of Hornstone. The lower are more slaty, and of a blue colour. This deposit, while it preserves throughout its siliceous character, as it extends in the direction of the dip, becomes more slaty in its structure, until in fact it passes into a true siliceous slate, reposing immediately upon the last mentioned coal seam. This is the form under which it appears at Mr. Faurer's coal bank a short distance above Charleston. The siliceous shales or slates immediately resting on the coal, gradually pass

into a more compact slate, and finally into siliceous rock. The stratum is here about 7 feet in thickness. As seen in the section, this formation is covered with a thin band of impure iron ore, in kidney shaped masses, embedded in sandstone—the whole thickness not exceeding 4 inches. Farther down the river the iron disappears, giving place to ferruginous shales and sandstones, which immediately overlie the siliceous rocks.

No. 10. Resting on the above, there next occurs a heavy bed of yellow coarse siliceous sandstone, argillaceous in some bands, and quite prone to disintegration. This is surmounted by a more siliceous band of the same rock, occasionally quite cellular, and including fossil impressions of shells, Encrini, &c. This band contains a notable portion of lime. Thickness 140 feet.

No. 11. The section of Vineyard Hill is terminated by a thin capping of about 10 feet of reddish and yellow shales, the lower portion of which contains disintegrated masses of argillaceous iron. This may be regarded as the commencement of the series of shales, which along with shaly sandstones and thin calcareous bands, overspread nearly the whole of the tract lying between Charleston and the Ohio at the mouth of the Kanawha, presenting for the greater part of that distance a nearly uninterrupted, but very gentle dip towards the NW., then becoming horizontal, and finally near the Ohio rising with a counter dip and forming the middle portion of our great western coal basin. These strata, all higher geologically than the flint rock, and containing two or more coal seams where penetrated by the Ohio, constitute in this region what was formerly described as the *upper coal series.*

SECTION VII.

OPERATIONS OF THE SURVEY IN THE NORTHWESTERN DISTRICT.

Our investigations in the extensive and highly interesting portions of the state referred to under this head, were for the most part of a preliminary nature, being chiefly directed to the determination of certain general features of their geology which might serve as useful guides in conducting our future explorations.

Referring to the sketch formerly given of the outlines of the great coal region, it will be remembered that the boundary of this tract towards the north is marked by a broad and gently inflected curve, crossing from Ohio into Pennsylvania, some distance north of the most northern part of Virginia in Brooke county; and that as it extends eastwards, this line gradually sweeps around so as at length to assume a southwesterly direction along the western slope of the range of highlands known in Pennsylvania as Chesnut Ridge, and in Virginia as Laurel Hill. From the general description included in the sketch referred to, it will at once be seen that the *lower coal series* must occupy that portion of the basin lying adjacent to this margin, while the *upper* will be found overspreading a zone more towards the middle of the

trough; and that the dip of the strata, unless where modified by merely local causes, will conform to that of the corresponding parts of the margin, being southerly towards the northern, and westerly towards the eastern limits of the basin.

Setting out with this general view of the structure of the basin, our first object, and that to which attention was chiefly directed during the past season, was the tracing of the two great groups of strata, the lower and upper coal series from the Ohio around to the Monongahela, and in a southwesterly direction parallel to the course of Laurel Hill, and in marking the limits of these groups by sections from the Ohio to the outcrop of the lowest strata of the coal measures some distance to the east of Morgantown and Clarksburg.

By these examinations the general outlines of the tracts occupied by each of the two great groups, and the important changes occurring in their component strata as they are prolonged towards the south, were in a general way ascertained, at the same time that numerous observations of a more detailed nature, accompanied by measured sections, were made at several important localities.

In the present stage of our enquiries regarding this region, it would obviously be premature to attempt giving any details relating to its geological features. Its general outline and structure have been described in sketching those of the entire basin, under a preceding head. Of the high economical importance of large portions of this area the fullest evidence has already been attained, nor can it be doubted that the systematic explorations to be resumed at the commencement of the coming season, will contribute in an important measure to the knowledge and practical development of its ample resources.

Of the composition of several of the iron ores, coals and limestones of this district, some details will be found in the concluding section of the report, to which I now proceed.

SECTION VIII.

CHEMICAL DETAILS.

The following details relating to the chemical composition of some of the more valuable materials appertaining to the various districts referred to in the present report, will be introduced in the order in which the geological descriptions have been presented, beginning with the tertiary marl and closing with the coal, iron ores, and limestones of the great western coal field. After what has already been remarked, it is needless to say that they constitute but a part of the whole body of chemical results hereafter to be given to the public in systematic shape, and are presented now chiefly as illustrations of the preceding sections of this report.

CHAP. 1.

Miocene Marls of the District South of the James river.

In drawing up the following tabular view of the amount of carbonate of lime contained in the marls of this portion of the state, it will be seen that I have included a number of results published in former reports, as well as such as have been obtained by more recent examinations. Such a comprehensive table, including nearly all the important localities south of the James river, will, it is thought, serve a useful purpose by bringing into one view almost every variety of marl met with in the district, and seems to be rendered particularly desirable by the fact, that from the inconvenient form and small edition of preceding reports, but few of those who feel interested in such results, have ever possessed or now retain copies of the publications in which they were made known.

Localities.	Observations.	Carb. Lime.
Isle of Wight.		
Mr. H. Day's, -	Perfect shells and fragments, sometimes cemented, green sand a trace, - - - - - -	76.1
Do. -	Ferruginous rock marl, semi-crystalline, green sand a trace,	77.2
Mr. Saunders's, -	(2d stratum)—yellow, small friable fragments of shell, considerable green sand, - - - -	48.8
Do. -	(3d stratum) ditto, - - -	60.2
Do. -	Ditto, - - -	42.0
James Pedin's, -	Light, shells entirely decomposed, nodular, green sand a trace, - - - - - -	54 5
Day's Point, -	Blue, friable, micaceous and sandy, - - -	7.9
G. Purdie's, -	Shells and fragments in a light tenacious clay, frequently rich in indurated casts of the chama, green sand a trace, sometimes a fragmentary conglomerate, - -	71.5
Do. -	Ditto, - - -	62.5
Do. -	Conglomerate, ditto, - - -	81.8
Do. -	Ditto, - - - - -	63.6
Mr. White's, -	A conglomerate of perfect shells and fragments, ferruginous and semi-crystalline, very compact, - -	91.3
Mr. S. P. Jordan's,	Very comminuted fragments of shell in a ferruginous sand, green sand a trace, - - - -	53.4
Do. -	Ditto, - - -	79.5
Merit Todd's, -	Light, rather tenacious, shells decomposed, green sand a trace, - - - - - -	28.4
Do. -	A conglomerate of small shells and fragments, intermixed with a ferruginous sand, tinged with green sand, -	42.0
Rocks, -	Blue, arenaceous, very friable, containing a few small cythereas, - - - - - -	7.95
Do. -	A coarse shelly conglomerate, yellow, occasionally a cast of the chama, - - - - -	78.4
Mr. Booth's, -	Of a very light yellow colour, containing small fragments, frequently cemented, - - - -	64.7
Do. -	Shells decomposed, concretionary, - - -	71 5
John Y. Mason's, -	Mactra modicella in a yellow sand, with a few other shells and fragments, green sand a trace, - -	35.2
Nansemond.		
Town Point, -	Ferruginous, consisting of small shells and fragments, -	67.5
2 miles above town Point, -	Ditto, - - -	52.3

Localities.	Observations.	Carb. Lime.
Mr. Keeling's, -	Small shells and fragments in a light sand, also fragments of the pecten, sometimes conglomerated, - -	75.0
Do. -	More ferruginous, containing fewer shells, - -	30.6
Below Dumpling Island, -	A conglomerate of fragments, quite compact, - -	65.2
Do. -	Finely comminuted shelly matter, deeply tinged with iron,	71.5
Mr. Cowper's, -	Ferruginous, consisting chiefly of fine fragments, -	72.7
Near Suffolk, -	Ditto, ditto, green sand a trace, -	17.0
Upper shore of Nansemond river, (near the mouth), -	Small fragments of shell, with perfect shells intermixed, ferruginous, - - - - -	82.9
Point above Sleepy Hole ferry, -	Principally chamas and crepidulas, intermixed with yellow sand, - - - - -	43.2
Near Suffolk, -	Blue, containing finely divided shelly matter, -	22.7
Upper shore (near Sleepy Hole ferry)	Blue, containing fine and coarse fragments of small shells,	30.6
Col. Corbell's, -	Small fragments of shell, ferruginous, - -	62.5
Do. -	Ditto, - - -	76.2
Maj. Crocker's, -	Ditto, - - -	64.7
Do. -	Ditto, - - -	26.0
W. H. Goodwin's,	Ditto, - - -	53.4
Mr. Phillips's, -	Ditto, - - -	80.6
Near Chucatuck mill, -	Ditto, - - -	82.9
Surry.		
Mrs. Faulcon's, -	Yellow, consisting of decomposed shells and fragments, occasionally slightly cemented, - - -	64.5
3 or 4 miles above Four Mile tree, -	Fragments of shell in a white sand, slightly intermixed with green sand, - - - -	47.2
Do. -	A yellow conglomerate of shells and casts, - -	75.00
Near Four Mile tree,	Fragments of shells and undecomposed shells, -	82.5
Mr. Organ's—Clermont, -	Yellowish white, fine and friable, occasionally concretionary, - - - - - -	71.5
Wakefield, -	Light, shells generally decomposed, a few fragments in a white sand, green sand a trace, - - -	51.1
Do. -	Blueish, shells very much decomposed, - -	75.0
Douglas's, -	White indurated casts of chamas, - - -	87.5
Clermont (river shore), -	Blue, largely intermixed with green sand, shells finely decomposed, - - - - - -	10.2
Upper Chipoke creek, -	A calcareo-silicious conglomerate, very compact, containing fragments of pectens and casts of pernas, -	55.6
Stithes, -	Small fragments of shell in sand, a good many chamas, quite richly specked with green sand, - -	42.0
Do. -	Ditto, - - -	33.0
River shore (above the mouth of College creek), -	Consisting of fragments of the chama in a light sand, -	144.3
A. C. Jones's, -	Shells and fragments in a light sand, intermixed with green sand, - - - - - -	53.2
Booth's mill; Terrapin creek, -	Yellow marl, mactra mod. almost exclusively, sandy clay, with a little green sand, - - - -	32.7
Joseph Pretlow; Terrapin run, -	Yellowish grey marl, mactra mod., siliceous sand, with a little green sand, - - - -	22.3

Localities.	Observations.	C
Blackwater, near Wall's bridge, -	Mactra mod. in a yellow sandy clay, considerable green sand, - - - - -	
Southampton.		
Nottoway swamp, one mile from mouth, Massenburg's mill, -	Bluish grey marl, shells, chiefly venus, much decomposed, in a siliceous clay, with much green sand, - -	
Six miles SE. of Jerusalem, Mr. Massenburg's, -	Yellow fragmentary marl, with small shells often entire, but water-worn, chiefly mactra mod., plicatula, marginella, - - - - -	
Monroe, on Nottoway river, -	Bluish grey marl, containing chama, astarte, venericardice and fragments of pecten, in a siliceous clay, with green sand, - - - - -	
Blackwater river, one and a half miles north of Leacock, Mr. Hering, -	Yellow marl, shells in great variety, chiefly mactra mod., turritella, ostrea, chama, crassatella, in a sandy clay, with considerable green sand, - - -	
Nottoway river, above Monroe, -	Blue marl, shells, mactra mod., ostrea, turritella, &c., in a sandy clay, with a good deal of green sand, -	
Same locality, -	Ditto, - - -	
Blackwater river, above mouth of Black creek, Mr. Lawrence, -	Light brownish grey, shells, mactra mod. almost entirely in an adhesive clay, with a little green sand, -	
Same locality, -	Ditto, - - -	
Two miles NW. of Franklin, Dr. Bowers, -	Mottled brown and grey, shells, ostreas in a soft decomposing state in a siliceous clay, with a little green sand,	
Br. of Terrapin Swamp, Ro. Pretlow, -	Blue marl, shells entire, and almost exclusively mactra mod.	
Blackwater river, above the mouth of Black creek, Mrs. Ely, -	Grey marl, mactra mod in clay, with a considerable amount of green sand, - - - -	
Nicholson's mill, -	Mactra mod. in a yellow sandy clay, sandy residuum, with a trace of green sand, - - - -	
Major Ridley's, -	Dingy yellow, tenacious, shells entirely decomposed, sandy residuum, green sand a trace, - - -	
Do. -	Indurated nodular marl, shells decomposed, sandy residuum, green sand a trace, - - -	
Capt. Briggs, -	Large shells and fragments in blue sand, a trace of green sand, - - - - -	
Do. -	Compact lump marl containing casts and impressions of shells, green sand a trace, - - -	
Mr. Ivey, -	Perfect shells in a yellow sandy clay, a trace of green sand,	
Blackwater, nearly opposite mouth of Burke's run, Mr. Bowden, -	Yellowish brown cemented marl, siliceous with a very little green sand, upper part of the bank, - -	

Localities.	Observations.	Carb. Lime.
Mr. Bowden, on a run making into the river, -	Bluish green marl, shells in considerable variety, chiefly mactra mod. with turritella, natica, &c., much green sand, - - - - -	31.3
Above Broadwater bridge, Mr. Urquhart, -	Yellow marl, shells, mactra mod. exclusively, green sand,	27.3
Benj. Drew, near the Sussex line, -	Light grey marl, somewhat chalky, shells much decomposed, consisting chiefly of mactra mod. - -	46.1
Two miles NW. of Franklin, Dr. Bowers, -	Yellow sandy marl, shells much decomposed, consisting chiefly of mactra mod. - - - -	16.0
North Carolina.	The following two specimens, though from localities a little beyond the limits of the state, are included in the table, by way of shewing the extension of the blue and yellow marls into Carolina.	
Mr. Wood's, a little west of the Meherrin river and south of the state line, -	Yellow marl, shells, mactra mod., lucina, &c., in a mixture of yellowish sand and clay, a trace of green sand,	45.4
Do. -	Blue marl, shells chiefly mactra mod. in bluish clay, a good deal of green sand, - - - -	30.7
Sussex.		
Col. Blow's, -	Upper stratum, mactra mod. in yellow sandy clay, green sand a trace, residuum ferruginous sand, - -	36.3
	From the calcareous portion of the grey marl, dingy white, indurated, considerable green sand, - -	63.6
	From the middle of the grey marl, no shells, occasional fragments, a mixture of white and green calcareous sand, - - - - - -	31.6
Wm. H. Pegram,	Mactra mod. in blue tenaceous sandy clay, residuum sandy, - - - - -	28.1
Wm. H. Pegram, Chinquapin Run,	Sandy residuum, green sand a trace, - -	35.2
Do. -	Mactra mod. in yellow tenaceous clay, considerable green sand, residuum sandy, - - - -	33.0
Col. Gee, -	Dingy yellow, comminuted fragments of shells in a clayey sand, green sand a trace, - - -	42.9
Henry Birdsong,	Mactra mod. in a blue tenaceous clay, sandy residuum, green sand a trace, - - - -	39.5
Do. -	Mactra mod. in yellow tenaceous clay, sandy residuum, considerable green sand, - -	32.7
Maj. Pacham's mill,	Mactra mod. chiefly, in a blue clay, aluminous residuum, a trace of green sand, - - -	39.0
Mrs. Blunt, -	Compact and indurated, light grey, containing casts of shells, residuum chiefly green sand, - -	79.7
Do. -	Great variety of perfect shells in a blue sand; sandy residuum, considerable green sand, - - -	30.3
	Mactra mod. in blue sandy clay. A trace of green sand,	31.3
Mr. Mason's, -	Indurated lump marl; bluish grey, containing casts and impressions of shells and a trace of green sand, -	70.4
Do. -	Comminuted fragments of shells in blue sandy clay with perfect shells; a trace of green sand, - -	50.4
Harrison's mill, -	Average character of upper marl, bluish white shells generally decomposed, - - - -	57.9
Do. -	Lower portion of the bed, compact indurated lumps with casts and impressions of shells, - - -	59.0

Localities.	Observations.	Carb. Lime.
Prince George.		
Coggin's Point, -	Small shells and fragments in a yellow sand, green sand a trace, - - - - - -	28.4
Mr. Prentice's, -	A great variety of shells in sand, - - -	53.6
Evergreen, -	Fragments of shells in a light sand, - -	32.9
Tarbay, -	Ditto, - - -	19.4
Mr. Bryant, -	Indurated lump marl, dingy colour, containing casts and impressions of shells and small fragments, none perfect,	61.3
Do. -	Deep yellow, perfect shells contained in very comminuted fragments, sandy residuum with a trace of green sand,	20.9
M. Smith, -	Lower portion of the marl, a conglomerate of small bivalve shells, chiefly chama congregata—considerable green sand, - - - - - -	63.6
Do. -	Upper portion consisting wholly of mactra mod. in a blue clay, green sand a trace, - - -	25.0
Greensville.		
Mr. Reeve's, -	Large shells and fragments in blue sand, a large number of the genus bolanus, green sand a trace, -	28.6

CHAP. 2.

Limestones associated with the Micaceous and Talcose Rocks of the Southern District.

Under a former head, mention has been made of the highly magnesian character of some of the limestones here referred to. The details which follow will serve to shew the variable composition of these rocks as procured from different localities, and at the same time will fully sustain what was formerly asserted of the value of the lime which some of these beds are capable of furnishing. Of the hydraulic character of certain varieties, some notice is taken below, and additional and more prolonged trials remain yet to be performed. Until these are completed, no confident affirmation can be made of the great excellence of any of these limes as water cements, though with regard to several of them, the capacity of slowly setting under water has been fully ascertained by the experiments in which I am now engaged.

1. Limestone from Mr. Wright's, east of Beaver creek, Campbell county. Colour light grey, with dark stripes, micaceous; texture compact, crystalline; fracture splintery.

Carbonate of lime, - -	16.89
Carbonate of magnesia, - -	6.32
Alumina and oxide of iron, -	1.00
Silica, - - - -	0.67
Water, - - - -	0.12

2. Limestone from Arthur's quarry on Back creek, NW. of Leesville, Campbell county. Colour light blue, with grey stripes; texture rather compact; fracture rather splintery; structure slaty; crystalline.

Carbonate of lime,	- -	23.19
Carbonate of magnesia,	- -	0.61
Alumina and oxide of iron,	-	0.14
Silica,	- - - -	0.96
Water,	- - - -	0.10

3. Limestone from Elk creek, Nelson county, used as flux at the furnace in the vicinity. Colour bluish grey, micaceous; texture rather compact; crystalline.

Carbonate of lime,	- -	20.87
Carbonate of magnesia,	- -	0.72
Alumina and oxide of iron,	-	0.38
Silica,	- - - -	2.88
Water,	- - - -	0.15

4. Limestone from captain Perrow's, Beaver creek, Campbell county. Colour pure white; texture compact, crystalline; grain rather fine; fracture conchoidal.

Carbonate of lime,	- -	13.94
Carbonate of magnesia,	- -	10.18
Alumina and oxide of iron,	-	0.39
Silica,	- - - -	0.38
Water,	- - - -	0.11

5. Limestone from James river canal between Elk creek and Greenway, Nelson county. Colour white; texture compact; crystalline; fracture conchoidal; contains disseminated small crystals of quartz.

Carbonate of lime,	- -	16.03
Carbonate of magnesia,	- -	7.58
Alumina and oxide of iron,	-	0.49
Silica,	- - - -	0.78
Water,	- - - -	0.12

6. Limestone from south side of James river opposite Warminster, Buckingham county. Colour pink, mottled with grey; texture rather compact; subcrystalline; grain moderately fine; fracture conchoidal; hydraulic.

Carbonate of lime,	- -	11.17
Carbonate of magnesia,	- -	8.50
Alumina and oxide of iron,	-	1.04
Silica,	- - - -	4.12
Water,	- - - -	0.17

7. Limestone from Pounding Mill creek, near New Market, Nelson county; colour light pink; texture compact; grain moderately fine; fracture sharp, scaly.

Carbonate of lime,	- -	12.95
Carbonate of magnesia,	- -	10.80
Alumina and oxide of iron,	-	0.28
Silica,	- - - -	0.88
Water,	- - - -	0.09

9. Limestone from judge Saunders's, Flat creek, Campbell county. Colour blue; structure slaty.

Carbonate of lime,	- -	51.3

10. Limestone from James river below Archer's creek, Campbell county. Colour grey; subcrystalline with small rhombs of calc. spar.
Carbonate of lime, - - 79.5

11. Limestone from one half mile NW. of Dyer's mill, Albemarle county. Blue, slaty, alternating with white laminæ.
Carbonate of lime, - - 77.2

12. Limestone from Arthur's quarry, near Leesville, Campbell county. Bluish grey, micaceous, containing masses of calc. spar.
Carbonate of lime, - - 80.

13. Limestone from one mile above New Market, Nelson county, quarried for locks on the James river canal. Blue, compact, and traversed by veins of flesh coloured carb. lime.
Carbonate of lime, - - 79.5

14. Limestone from James river canal, 2 miles below Warminster, Nelson county. Blue, slaty, micaceous, with calc. spar.
Carbonate of lime, - - 72.7

15. Limestone from captain Tardy's, near Otter river, Campbell county. Bluish, granular, micaceous.
Carbonate of lime, - - 59.

16. Limestone from Ro. Irvine's Buffalo creek, Campbell county. Light grey, slightly micaceous and subcrystalline.
Carbonate of lime, - - 87.3

17. Limestone from Hancock's quarry, Limestone run, Albemarle county. Blue and slaty.
Carbonate of lime, - - 60.5

18. Limestone from Ross's furnace, Stonewall creek, Campbell county. Light bluish grey; granular; subcrystalline.
Carbonate of lime, - - 88.4

19. Limestone from near Elk creek, Nelson county, quarried for locks. Dark blue, slaty, and slightly micaceous.
Carbonate of lime, - - 65.5

20. Limestone from Rives's quarry, near Brooks's, Franklin county. Blue micaceous laminæ, alternating with white subcrystalline carb. lime.
Carbonate of lime, - - 64.5

21. Limestone from James river canal, between Fishing creek and Opossum creek. Wwhite slaty, surface talcose.
Carbonate of lime, - - 25.

22. Limestone from Buck Island creek, Albemarle county. Colour dark blue, with white veins of spar; texture rather compact; grain moderately fine.
Carbonate of lime, - - - 76.4

CHAP. 3.

Limestones of Formation II.

The annexed details relating chiefly to the highly magnesian varieties of this formation, while serving to confirm the observations made in previous reports, as regards the hydraulic properties of this class

of limestones, will, it is hoped, prove useful in pointing out a number of localities of cement rocks not referred to in former publications.

1. Limestone from near the Trap Dyke, 8½ miles west of Mount Crawford, Rockingham county. Colour light grey; texture rather compact; subcrystalline; inclining to granular; fracture rough; hydraulic. In the 25 grains, this consists of

Carbonate of lime, - -	13.50 grains.
Carbonate of magnesia, - -	10.56
Alumina, tinged with oxide of iron, -	0.38
Silica, - - - -	0.39
Water, - - - -	0.12

2. Limestone from the eastern base of Price's mountain, Botetourt county. Colour light bluish grey; texture compact; fracture slightly conchoidal; grain moderately fine; highly hydraulic.

Carbonate of lime, - -	12.96
Carbonate of magnesia, - -	9.35
Silica, - - - -	2.09
Alumina and oxide of iron, - -	0.37
Water, - - - -	0.14

3. Limestone from slaty beds in II., Liberty road, 3 miles north of Big Lick, Roanoke county. Colour dark bluish grey; moderately compact; slightly subcrystalline; fine grained; containing disseminated small specks of iron pyrites, and enclosing geodes of sulphate of lime; very hydraulic.

Carbonate of lime, - -	11.55
Carbonate of magnesia, - -	8.54
Alumina and oxide of iron, - -	1.00
Sulphuret of iron, - -	0.23
Silica, - - - -	3.17
Water, - - - -	0.15

4. Limestone from Rich valley opposite the Salt works, Washington county. Colour bluish white; compact; fine grained; hydraulic.

Carbonate of lime, - -	12.52
Carbonate of magnesia, - -	10.38
Alumina, tinged with oxide of iron, -	0.18
Silica, - - - -	1.85
Water, - - - -	0.07

5. Limestone from locality 1½ mile east of Cedar Grove, Rockbridge county. Colour bluish grey; texture compact; grain moderately fine; fracture slightly conchoidal; hydraulic.

Carbonate of lime, - -	12.53
Carbonate of magnesia, - -	8.97
Alumina and oxide of iron, - -	0.52
Silica, - - - -	2.82
Water, - - - -	0.16

6. Limestone from south side of Shenandoah river, 2 miles from Blackford's furnace, Page county. Colour very light brown and drab; texture compact; grain fine; fracture rather smooth and slightly conchoidal; hydraulic.

Carbonate of lime,	- -	13.01
Carbonate of magnesia,	- -	10.45
Alumina with trace of oxide of iron,		0.30
Silica,	- - - -	1.17
Water,	- - - -	0.07

7. Limestone from locality 4 miles south of New Market. Colour light bluish grey; texture compact; grain moderately fine; weathered surface tinged with oxide of iron; hydraulic.

Carbonate of lime,	- -	13.50
Carbonate of magnesia,	- -	10.63
Alumina and oxide of iron,	- -	0.17
Silica,	- - - -	0.60
Water,	- - - -	0.10

8. Limestone from lower stratum at Dr. Blackford's mill race, Page county. Colour light blue, inclining to grey; texture compact; grain moderately fine; slightly subcrystalline; some portions of surface filmed with white calc. spar; very hydraulic.

Carbonate of lime,	- -	13.40
Carbonate of magnesia,	- -	9.78
Alumina and oxide of iron,	- -	0.19
Silica,	- - - -	1.47
Water,	- - - -	0.16

9. Limestone from locality a little south of Abingdon. Colour bluish grey; texture compact; grain fine; fracture small conchoidal; hydraulic.

Carbonate of lime,	- -	19.55
Carbonate of magnesia,	- -	2.54
Alumina and oxide of iron,	- -	0.28
Silica,	- - - -	2.51
Water,	- - - -	0.12

10. Limestone from locality 6 miles NW. of Pattonsburg, on road to Crawford's mountain. Colour dark bluish grey; texture compact; fracture rather earthy, and slightly conchoidal; hydraulic.

Carbonate of lime,	- -	11.58
Carbonate of magnesia,	- -	9.32
Alumina and trace of oxide of iron,	-	0.76
Silica,	- - - -	3.09
Water,	- - - -	0.25

11. Limestone from bed passing a little west of Waynesboro', Augusta county. Colour light blue; texture compact; grain fine; fracture slightly conchoidal; weathered surface, tinged with per oxide of iron; very hydraulic.

Carbonate of lime,	- -	12.33
Carbonate of magnesia,	- -	9.58
Alumina and oxide of iron,	- -	0.57
Silica,	- - - -	2.36
Water,	- - - -	0.16

12. Limestone from Catawba creek, near Stone Coal gap. Colour dark bluish grey; texture compact; grain moderately fine; fracture rather uneven; very hydraulic.

Carbonate of lime,	- -	11.16
Carbonate of magnesia,	- -	9.38
Alumina and oxide of iron,	- -	0.62
Silica,	- - - -	3.59
Water,	- - - -	0.25

13. Limestone from gap of Peter's mountain, north side of New river, 4 miles from Grey Sulphur springs. Colour greenish grey; texture compact; grain rather fine; fracture rather undulating; hydraulic.

Carbonate of lime,	- -	11.17
Carbonate of magnesia,	- -	8.31
Alumina and oxide of iron,	- -	1.06
Silica,	- - - -	4.27
Water,	- - - -	0.19

14. Limestone from near the mouth of Wolf creek, Giles county. Colour light grey; weathered surface, tinged with oxide of iron; texture rather friable; crystalline; fractured surface, rough and seemingly arenaceous; hydraulic.

Carbonate of lime,	- -	13.23
Carbonate of magnesia,	- -	10.99
Alumina and oxide of iron,	- -	0.14
Silica,	- - - -	0.55
Water,	- - - -	0.09

15. Limestone from locality 3 miles north of Abingdon. Colour dark blue; texture compact; grain fine; fracture rather smooth and slightly conchoidal; very hydraulic.

Carbonate of lime,	- -	15.30
Carbonate of magnesia,	- -	7.11
Alumina and oxide of iron,	- -	0.23
Silica,	- - - -	2.17
Water,	- - - -	0.19

16. Limestone eight miles north of Fincastle, on road to Dibbrel's spring. Colour dark bluish grey; texture compact; slaty; grain fine; fracture slaty conchoidal; very hydraulic.

Carbonate of lime,	- -	9.29
Carbonate of magnesia,	- -	7.31
Alumina, tinged with oxide of iron,	-	1.29
Silica,	- - - -	6.93
Water,	- - - -	0.10

17. Limestone from west base of Little Fort mountain, opposite Woodstock. Colour light bluish grey; texture compact; grain fine; fracture smooth conchoidal; very hydraulic.

Carbonate of lime,	- -	12.63
Carbonate of magnesia,	- -	10.12
Alumina and oxide of iron,	- -	0.48
Silica,	- - - -	1.52
Water,	- - - -	0.15

18. Limestone from Roaring run, foot of the Two Pointers (mountains), Botetourt. Colour dark bluish grey; texture compact; grain moderately fine, subcrystalline; fracture sharp conchoidal; very hy-

Carbonate of lime,	- -	12.52
Carbonate of magnesia,	- -	7.83
Alumina and oxide of iron,	- -	0.62
Silica,	- - - -	3.90
Water,	- - - -	0.13

CHAP. 4.

Limestones of Formation VI.

1. Limestone from Patterson's creek, near Hampshire furnace. Colour greyish drab; weathered surface tinged with per-oxide of iron; texture rather compact; subcrystalline; grain moderately fine; structure slaty.

Carbonate of lime,	- -	23.11
Carbonate of magnesia,	- -	0.35
Alumina and oxide of iron,	-	0.19
Silica,	- - - -	1.24
Water,	- - - -	0.17

2. Limestone from Little Ridge, near the Bloomery, Hampshire county. Colour dull bluish grey; texture compact; grain fine; crystalline specks; fracture rather conchoidal; hydraulic.

Carbonate of lime,	- -	11.66
Carbonate of magnesia,	- -	7.67
Alumina and oxide of iron,	-	1.58
Silica,	- - - -	3.90
Water,	- - - -	0.19

CHAP. 5.

Limestones of Formation XI.

It will be apparent from the following details, that this formation includes beds of limestone of remarkable purity, and adapted to furnish a lime well suited to architectural as well as household and agricultural purposes. Where widely developed, as in Greenbrier and Monroe, extensive beds are found in it, containing a considerable proportion of carbonate of magnesia, by which, together with the accompanying silica, they are fitted for the manufacture of water cement. Layers of this description are also met with in the northern portion of the state, and within the general limits of the coal region, an example of which is presented below in the specimen from the Cheat river, near the mouth of Laurel run. Numerous other instances of the occurrence of magnesia and hydraulic bands in this formation will no doubt be brought to light by further geological and chemical investigations.

The value of these limestones generally is sufficiently illustrated by the fact, that, excluding the specimen containing a large amount of magnesia, the average proportion of carbonate of lime in those enumerated below is about 86 per cent., indicating a degree of purity

equal to that of the better class of dark blue limestones belonging to formation II., as they are spread out in our great valley.

The last six specimens in the following list having been found devoid of magnesia, were analyzed no further than to ascertain the percentage of carbonate of lime.

1. Limestone from the neighbourhood of the Red Sulphur springs, Monroe county. Colour bluish black; texture compact; grain fine; fracture smooth conchoidal.

Carbonate of lime, - -	22.73
Carbonate of magnesia, - -	a trace.
Alumina and oxide of iron, -	0.30
Silica, - - - -	1.55
Water, - - - -	0.11
Bituminous matter.	

2. Limestone from Muddy creek mountain, near Blue Sulphur spring. Colour light grey; texture compact; grain fine; fracture sharp conchoidal. This rock is beautifully oolitic.

Carbonate of lime, - -	24.55
Carbonate of magnesia, - -	0.00
Alumina and oxide of iron, -	0.12
Silica, - - - -	0.10
Water, - - - -	0.06

This, like all the other light coloured oolitic specimens from this formation, is remarkably pure, containing, as will be seen by the above result, upwards of 98 per cent. of carbonate of lime.

3. Limestone from near Union, Monroe county. Colour bluish grey; texture compact; subcrystalline; fracture sharp conchoidal.

Carbonate of lime, - -	23.98
Carbonate of magnesia, - -	a trace.
Alumina and oxide of iron, -	0.14
Silica, - - - -	0.47
Water, - - - -	0.10

4. Limestone from the inferior portion of formation No. XI., Cheat river, three fourths mile below the mouth of Laurel run. Colour lead grey, with a greenish yellow tinge; texture compact; grain moderately fine; fracture irregular, earthy; *very hydraulic.*

Carbonate of lime, - -	10.40
Carbonate of magnesia, - -	6.48
Alumina and oxide of iron, -	2.42
Silica, - - - -	5.00
Water, - - - -	0.31

5. Limestone from superior portion of XI., east side of Laurel Hill axis, Monongalia county, used as a flux at the Greenville furnace. Colour spots of light yellow and grey; texture compact, partially subcrystalline; fracture uneven and rather smooth.

Carbonate of lime, - -	22.08
Alumina and oxide of iron, -	0.63
Silica, - - - -	1.81
Water, - - - -	0.18

6. Limestone from lower part of XI., used at Jenkins's lin Cheat river, below the mouth of Gum Comp run. Colour lead texture compact, slightly subcrystalline; fracture irregular.

Carbonate of lime,	- -	22.44
Carbonate of magnesia,	- -	0.58
Alumina and oxide of iron,	. -	0.29
Silica,	- - - -	1.45
Water,	- - - -	0.23

7. Limestone from XI., Cheat river, below Gum Comp run, ton county. Colour light grey, with stripes of blue; texture con fracture rough plain surface, seemingly arenaceous.

Carbonate of lime,	- -	16.85
Carbonate of magnesia,	- -	0.58
Alumina and oxide of iron,	-	0.22
Silica,	- - - -	6.75
Water,	- - - -	0.14

8. Limestone from XI., Richard Forman's plantation, P county. Colour lead grey; texture compact, subcrystalline; fine; fracture slightly conchoidal.

Carbonate of lime,	- -	22.95
Carbonate of magnesia,	- -	1.43
Alumina and oxide of iron,	-	0.10
Silica,	- - - -	0.34
Water,	- - - -	0.18

9. Limestone from XI., western side of Briery axis, two south of Kingwood, Preston county. Colour light grey; textur pact, partially subcrystalline; grain fine; fracture irregular.

Carbonate of lime,	- -	22.36
Carbonate of magnesia,	- -	0.70
Alumina and oxide of iron,	-	0.22
Silica,	- - - -	1.51
Water,	- - - -	0.21

10. Limestone from eastern side of Briery mountain, one ha north of the turnpike. Colour grey; texture rather compact, s subcrystalline; grain rather coarse.

Carbonate of lime,	- -	16.00
Carbonate magnesia,	- -	1.69
Alumina and oxide iron,	- -	0.40
Silica,	- - - -	6.74
Water,	- - - -	0.17

11. Limestone from front ridge of Alleghany, opposite the Fork gap in Knobly mountain. Colour dark bluish grey; t compact, subcrystalline; grain fine; fracture conchoidal, smo

Carbonate of lime,	- -	22.52
Carbonate of magnesia,	- -	1.00
Alumina and oxide of iron,	-	0.18
Silica,	- - - -	1.14
Water,	- - - -	0.16

12. Limestone from front ridge of Alleghany, opposite Peter Colour light lead; texture compact; subcrystalline; grain fine ture conchoidal.

Carbonate of lime,	- -	22.13
Carbonate of magnesia,	- -	0.81
Alumina and oxide of iron,	-	0.38
Silica,	- - - -	1.50
Water,	- - - -	0.18

13. Limestone from Everlie's mill, near the head of Youghioganey, western side of Briery axis, Preston county. Colour light grey; texture compact; subcrystalline fracture, slightly conchoidal. In the 100 grains,

Carbonate of lime, - - 92

14. Limestone from the lower part of XI., Decker's creek, Monongalia county. Colour light grey; compact, subcrystalline; fracture uneven.

Carbonate of lime, - - 84.5

15. Limestone from the middle of upper limestone of XI., western side of Briery axis, 4 miles south of Kingwood road. Colour light grey; compact and subcrystalline.

Carbonate of lime, - - 90.7

16. Limestone from the western side of Backbone axis on Red creek, 6 miles above its mouth, Randolph county. Colour light grey; texture compact, &c.

Carbonate of lime, - - 82.5

17. Limestone from western side of Briery axis, half a mile below the Kingwood, near Roaring creek, on land of Christian Smith. Colour grey, inclining to dun; texture, &c. as in the above.

Carbonate of lime, - - 69.5

18. Limestone from upper part of limestone of XI., a short distance west of Mount Carmel. Colour grey; texture, &c. as before.

Carbonate of lime, - - 84.5

CHAP. 6.

Limestones of the Coal Measures.

In presenting the following results, it gives me great pleasure to be able to announce the fact that by recent trials in my laboratory many of the bands of limestone included in the coal measures have been proved capable of furnishing a good *water cement*; and I would add, that the observations thus far made, lead to the belief that these *hydraulic layers* are of frequent occurrence, both in the *upper* and *lower* coal series. In connection with future explorations, therefore, particular attention will be directed to the chemical analyses of the calcareous rocks as presented at numerous localities not referred to below, and to the determination of their value as cements or for household and agricultural uses.

In relation to the results here given, it is proper to observe, that they are presented in a somewhat imperfect shape—the process of separating the alumina and oxide of iron not having been completed, and the amount of iron existing in the state of carbonate being now only in progress of examination. These particulars, however, are of

little or no economical importance, and would not affect in a sensible degree the amount of lime and magnesia here stated. I have therefore thought it advisable to exhibit a few such results, even though incomplete, as illustrating the characteristic features of some of the limestones under consideration. Numerous and very detailed analyses of these and other materials, of which partial reports have been from time to time presented, will be given hereafter.

1. Limestone from the vicinity of Morgantown, near Rogers's mill. Dove coloured; weathered surface ferruginous; texture compact; subcrystalline; grain fine; fracture irregular and rather smooth; *very hydraulic;* sets promptly and becomes very hard.

Carbonate of lime, - -	13.01
Carbonate of magnesia, - -	4.28
Alumina and oxide of iron, - -	2.15
Silica, - - - -	4.84
Water, - - - -	0.40

2. Limestone from coal rocks near Kingwood, Preston county, Mr. Hagan's. Colour dull bluish grey tinged with yellow; texture compact; grain fine; fracture conchoidal; specks of sulphuret of iron and calc. spar; *very hydraulic;* sets promptly and becomes very hard.

Carbonate of lime, - -	14.29
Carbonate of magnesia, - -	5.95
Alumina and oxide of iron, - -	2.28
Silica, - - - -	2.13
Water, - - - -	0.35

3. Limestone from Kanawha valley, beneath Stockton's coal seam, near steam mill. Colour dull dark grey; texture compact; grain rather coarse; fracture conchoidal; containing carbonaceous matter and specks of iron pyrites; *hydraulic.*

Carbonate of lime, - -	15.70
Carbonate of magnesia, - -	1.07
Alumina and oxide of iron, - -	1.60
Silica, - - - -	6.01
Water, - - - -	0.62

4. Limestone from Hughes's creek, Kanawha. Colour light bluish grey; texture compact; fracture slightly conchoidal; weathered surface earthy and ferruginous.

Carbonate of lime, - -	14.12
Carbonate of magnesia, - -	0.62
Alumina and oxide of iron, - -	1.75
Silica, - - - -	8.01
Water, - - - -	0.50

5. Limestone from beneath the middle seam of coal in the Kingwood basin. Colour lead blue; texture compact; grain fine; fracture irregular.

Carbonate of lime, - -	19.88
Carbonate of magnesia, - -	0.70
Alumina and oxide of iron, - -	0.78
Silica, - - - -	3.45
Water, - - - -	0.31

6. Limestone from one mile east of Brandonville, Preston county, Mr. Rhodoheaver's. Colour dull dark blue; texture compact; grain fine; fracture rather smooth.

Carbonate of lime,	-	-	16.02
Carbonate of magnesia,	-	-	2.28
Alumina and oxide of iron,	-	-	2.14
Silica,	- - -	-	4.03
Water,	- - -	-	0.32
Carbonate of iron,	- -	-	0.20

7. Limestone from band beneath the lower seam of coal in the Kingwood basin, colonel Fairfax's, 2½ miles southeast of Kingwood. Colour dark lead grey; texture compact; grain fine; fracture smooth, conchoidal.

Carbonate of lime,	-	-	20.35
Carbonate of magnesia,	-	-	0.83
Alumina and oxide of iron,	-	-	0.88
Silica,	- - -	-	2.56
Water,	- - -	-	0.31

8. Limestone from the magnesian band above the Wheeling coal seam. Colour light grey or drab; texture moderately compact; grain rather fine; fracture inclining to be earthy; *hydraulic.*

Carbonate of lime,	-	-	10.86
Carbonate of magnesia,	-	-	6.61
Alumina and oxide of iron,	-	-	1.10
Silica,	- - -	-	6.16
Water,	- - -	-	0.27

9. Limestone from the band adjoining the 2 feet seam of coal at Clarksburg, judge Duncan's. Colour dull bluish grey, with a light brownish tinge; texture compact; grain fine; fracture rather conchoidal.

Carbonate of lime,	-	-	23.88
Carbonate of magnesia,	-	-	0.47
Alumina and oxide of iron,	-	-	0.24
Silica,	- - -	-	0.23
Water,	- - -	-	0.18
Bituminous matter, a trace.			

10. Limestone from the band adjoining the large coal seam, Clarksburg, judge Duncan's. Colour dark bluish grey; texture moderately compact; grain moderately fine; fracture rough and splintery. This rock is under examination as a hydraulic cement, and from present appearances bids fair to shew striking hydraulic powers.

Carbonate of lime,	-	-	16.70
Carbonate of magnesia,	-	-	2.27
Alumina and oxide of iron,	-	-	1.10
Silica,	- - -	-	4.52
Water,	- - -	-	0.41
Bituminous matter, a trace.			

CHAP. 7.

Iron Ores of Formation XI. and of the Coal Measures.

1. Iron ore from formation XI., from the upper seam at the Grenville furnace, Laurel Hill, Monongalia county. Colour reddish brown or olive; weathered surface light brown or drab; texture compact; grain fine; fracture slightly conchoidal.

Carbonate of iron, - - -	23.27
Carbonate of lime, - - -	trace.
Carbonate of magnesia, - -	trace.
Silica, - - - -	1.12
Alumina, - - - -	0.20
Water and bitumen, - -	0.31
Carbonate of manganese, - -	trace.

2. Iron ore from XI., average specimen from "Rock vein," Grenville furnace. Colour bluish, inclining to grey; texture compact; grain rather fine; fracture earthy.

Carbonate of iron, - - -	16.08
Carbonate of lime, - - -	trace.
Carbonate of magnesia, - -	trace.
Silica, - - - -	6.80
Alumina, - - - -	1.04
Water and bitumen, - -	0.30
Carbonate of manganese, - -	a trace.

3. Iron ore from XI., "Rock vein" at the "Grenville works." Contains vegetable remains and numerous disseminated scales of mica. Colour grey; texture rather compact; grain moderately fine; fracture irregular, earthy.

Carbonate of iron, - - -	15.15
Carbonate of lime, - - -	a trace.
Carbonate of magnesia, - -	a trace.
Silica, - - - -	7.80
Alumina, - - - -	0.94
Water, - - - -	0.50
Carbonate of manganese, - -	a trace.

4. *Iron ore* from XI., "Lower vein" at Grenville furnace. Colour dull reddish brown; texture compact; fracture slightly conchoidal, disclosing minute scales of mica.

Carbonate of iron, - - -	17.79
Carbonates of lime and magnesia, -	0.35
Silica, - - - -	5.62
Alumina, - - -	0.74
Water, - - - -	0.41
Carbonate of manganese, - -	a trace.

5. Iron ore from XI., upper vein, Henry Clay furnace, Monongalia county. Colour grey with a reddish brown tint; texture compact; grain fine; fracture conchoidal; weathered surface ochreous.

Carbonate of iron, - - -	22.28
Carbonates of lime and magnesia, -	0.20

15. Iron ore from the Valley furnace as above, called by the miners kidney ore. Colour bluish grey, inclining to brown; weathered surface ochreous; texture compact; grain fine; fracture plane.

Carbonate of iron, - - -	19.55
Carbonate of lime, - -	1.10
Carbonate of magnesia, - -	0.75
Silica, - - - -	2.80
Alumina, - - - -	0.35
Water, - - - -	0.50
Carbonate of manganese, - -	a trace.

16. Iron ore from shales above the second seam at Brantzburg, North branch of Potomac. Colour greyish blue; texture compact; grain moderately fine; fracture irregular; weathered surface tinged with per-oxide of iron.

Carbonate of iron, - - -	17.17
Carbonate of magnesia, - -	0.78
Carbonate of lime, - -	0.45
Silica, - - - -	5.18
Alumina, - - - -	0.69
Carbonate of manganese, - -	a trace.
Water, - - - -	0.39

It will be remarked of the above analyses, that a trace of carbonate of manganese is stated as generally present, both in the ores of XI. and of the coal measures. In only two or three instances was its amount sufficient to be estimated, and in these cases it was found so inconsiderable as to be undeserving of note. With regard to several other specimens yet to be analysed, there are indications of a larger proportion of this ingredient. I would add that a precise determination of its amount will always be given where it is capable of being noted, or worthy of mention in an economical point of view.

COALS OF THE GREAT WESTERN COAL REGION.

FROM FORMATION XI.

Though not properly included in the coal measures, the coals of this formation being found either along the margin of the great basin or in the axes within its boundaries, are in general so contiguous to the seams of the lower coal series, that they may with propriety be treated of in the same connection.

1. Coal from Little Sewell, near the top, a short distance below formation XII. Composed of alternating shining and dull black laminæ. In the 100 grains, contains,

Carbon, - - - -	80.24
Volatile matter, - - -	17.48
Ash, - - - -	2.28

2. Coal from same locality; aspect the same as the foregoing.

Carbon, - - - -	77.64
Volatile matter, - - -	17.36
Ash, - - - -	5.00

FROM BIG SEWELL MOUNTAIN.

3. Coal from the east side of Big Sewell. Rogers's seam. Composed chiefly of shining jet black laminæ, with occasional thinner ones of dull black.

Carbon,	- - - -	75.88
Volatile matter,	- - -	22.32
Ash,	- - - -	1.80

4. Coal from west flank of Big Sewell. Tyree's bed. Composed of dull black laminæ.

Carbon,	- - - -	67.84
Volatile matter,	- - -	30.08
Ash,	- - - -	2.08

5. Coal from west side of Big Sewell. Deem's. Composed of jet black shining laminæ; fracture prismatic.

Carbon,	- - - -	71.73
Volatile matter,	- - -	27.13
Ash,	- - - -	1.14

FROM TRACT BETWEEN BIG SEWELL AND KANAWHA.

6. Coal from Mill creek, Fayette county. Paris & Wood's bank. Composed of shining black laminæ, with films of charcoal.

Carbon,	- - - -	71.88
Volatile matter,	- - -	26.20
Ash,	- - - -	1.92

7. Coal from Scrabble creek. Shining and compact.

Carbon,	- - - -	63.36
Volatile matter,	- - -	29.04
Ash,	- - - -	7.60

8. Coal from Bell creek. Dull and friable.

Carbon,	- - - -	
Volatile matter,	- - -	32.16
Ash,	- - - -	

FROM THE VALLEY OF THE KANAWHA.

LOWER COAL SERIES.

9. Coal from SW. side of Keller's creek. *Lowest seam.* Hansford's. Brilliant and compact.

Carbon,	- - - -	60.92
Volatile matter,	- - -	37.08
Ash,	- - - -	2.00

10. Coal from Stockton's mine, near mill. *Second seam.* Deep black; shining and compact.

Carbon,	- - - -	74.55
Volatile matter,	- - -	21.13
Ash,	- - - -	4.32

11. Coal from L. Ruffner's. Campbell creek, or *second seam.*

Carbon, - - - -	55.76
Volatile matter, - - -	32.44
Ash, - - - -	11.80

12. Coal from Noyes, Rand & Co.'s. Campbell's creek, or *second seam.*

Carbon, - - - -	64.16
Volatile matter, - - -	32.24
Ash, - - - -	3.60

13. Coal from Noyes, Rand & Co.'s. Campbell's creek, or *second seam.*

Carbon, - - - -	65.64
Volatile matter, - - -	31.28
Ash, - - - -	3.08

14. Coal from Cox & Hannah's. *Third seam.* Deep black, shining and compact.

Carbon, - - - -	51.41
Volatile matter, - - -	42.55
Ash, - - - -	6.04

15. Coal from Faure's bank. *Upper seam,* beneath the black flint.

Carbon, - - - -	53.20
Volatile matter, - - -	35.04
Ash, - - - -	11.76

16. Coal from *upper seam.* Daniel Ruffner's.

Carbon, - - - -	49.84
Volatile matter, - - -	44.28
Ash, - - - -	5.88

17. Coal from Bream's bank. *Third seam.*

Carbon, - - - -	57.76
Volatile matter, - - -	33.68
Ash, - - - -	8.56

18. Coal from Smither's bank.

Carbon, - - - -	54.52
Volatile matter, - - -	29.76
Ash, - - - -	15.76

19. Coal from Hughes's bank. Brilliant and compact.

Carbon, - - - -	62.32
Volatile matter, - - -	32.88
Ash, - - - -	4.80

20. Coal from Danl. Ruffner's. *Upper seam.*

Carbon, - - - -	57.28
Volatile matter, - - -	35.08
Ash, - - - -	7.64

21. Coal from Warth & English's.

Carbon, - - - -	54.00
Volatile, - - - -	39.76
Ash, - - - -	6.24

FROM THE HAMPSHIRE AND HARDY BASINS.

22. Coal from *lower seam*, Brantzburg, north branch of Potomac, 2 miles above the mouth of Savage.

Carbon,	- - - -	72.40
Volatile matter,	- - -	19.72
Ash,	- - - -	7.88

23. Coal from Oliver's tract—12 foot seam.

Carbon,	- - - -	79.08
Volatile matter,	- - -	16.28
Ash,	- - - -	4.64

24. Coal from Sigler's mine, near Westernport, *Maryland*—12 foot seam.

Carbon,	- - - -	82.60
Volatile matter,	- - -	15.76
Ash,	- - - -	2.64

25. Coal from Lonaconing, Maryland—12 foot seam.

Carbon,	- - - -	77.43
Volatile matter,	- - -	19.37
Ash,	- - - -	3.20

26. Coal from Macdonald's, Abraham's creek. *Third seam.*

Carbon,	- - - -	74.00
Volatile matter,	- - -	18.60
Ash,	- - - -	7.40

27. Coal from near the turnpike, 1 mile from top of Alleghany.

Carbon,	- - - .	77.12
Volatile matter,	- - -	19.60
Ash,	- - - -	3.28

28. Coal from Vandover's, near NW. turnpike.

Carbon,	- - - -	61.44
Volatile matter,	- - -	14.28
Ash,	- - - -	24.28

29. Coal from Kitzmiller's, Hardy county.

Carbon,	- - - -	79.76
Volatile matter,	- - -	15.48
Ash,	- - - -	4.76

30. Coal from falls of Stoney river, Hardy county. Lower seam.

Carbon,	- - - -	79.16
Volatile matter,	- - -	15.52
Ash,	- - . - -	5.32

31. Coal from Michael's, near Abraham's creek, 6 miles above the turnpike.

Carbon,	- - - -	72.40
Volatile matter,	- - -	15.20
Ash,	- - - -	12.40

32. Coal from Stoney river, 1 mile north of turnpike.

Carbon,	- - - -	83.36
Volatile matter,	- - -	13.28
Ash,	- - - -	3.36

33. **Coal from Michael's, upper part of seam.**

Carbon, - - - -	45.24
Volatile matter, - - -	14.96
Ash, - - - -	39.80

FROM PRESTON AND MONONGALIA BASINS.

LOWER COAL SERIES.

34. Coal from colonel Fairfax's, Kingwood basin. *Upper seam.*

Carbon, - - -	53.77
Volatile matter, - - -	31.75
Ash, - - -	14.48

35. Coal from do. do. *Middle seam,* 2½ miles from Kingwood.

Carbon, - - -	65.32
Volatile matter, - - -	27.77
Ash, - - -	6.91

36. Coal from Ro. Forman's basin southeast of Kingwood basin.

Carbon, - - -	73.68
Volatile matter, - - -	21.00
Ash, - - -	5.32

37. Coal from J. Martin's, branch of Deep Hollow creek, Preston county.

Carbon, - - -	65.42
Volatile matter, - - -	23.42
Ash, - - -	11.16

38. Coal from Mr. Beatty's, 3 miles from mouth of Buffalo Lick run.

Carbon, - - -	62.56
Volatile matter, - - -	29.60
Ash, - - -	7.84

39. Coal from Forman's mill, Big Sandy, 1 mile from Brandonville, Preston county. *Middle seam.*

Carbon, - - -	67.60
Volatile matter, - - -	22.40
Ash, - - -	10.00

40. Coal from Morton's, 1¾ mile NW. of Brandonville. *Upper seam.*

Carbon, - - -	65.28
Volatile matter, - - -	30.80
Ash, - - -	3.92

41. Coal from Mr. Price's, Cheat river, near Kingwood.

Carbon, - - -	60.36
Volatile matter, - - -	25.00
Ash, - - -	14.64

42. Coal from Mr. Seaport's, Big Sandy basin, west side of Big Sandy river.

Carbon, - - -	66.64
Volatile matter, - - -	27.12
Ash, - - -	6.24

43. Coal from Mr. Hagan's, Kingwood basin, 1 mile west of Kin wood.

Carbon, - - -	68.32
Volatile matter, - - -	26.48
Ash, - - -	5.20

44. Coal from same locality as above.

Carbon, - - -	67.28
Volatile matter, - - -	29.68
Ash, - - -	3.04

45. Coal from Mr. Wall's, Big Sandy basin, west side of Cheat.

Carbon, - - -	60.04
Volatile matter, - - -	26.88
Ash, - - -	13.08

46. Coal from Mr. Cresap's, ¾ mile SW. of Kingwood.

Carbon, - - -	64.24
Volatile matter, - - -	30.24
Ash, - - -	5.32

UPPER COAL SERIES.

47. Coal from *main seam* at Clarksburg. *Upper coal series.*

Carbon, - - -	56.74
Volatile matter, - - -	41.66
Ash, - - -	1.60

48. Coal from same seam. Cannel coal found near the middle the seam.

Carbon, - - -	49.21
Volatile matter, - - -	45.43
Ash, - - -	5.36

49. Coal from *main seam*, Pruntytown. The same with the Clark burg seam.

Carbon, - - -	57.60
Volatile matter, - - -	39.00
Ash, - - -	3.40

50. Coal from *main seam*, Morgantown. The same as the precedin

Carbon, - - -	60.54
Volatile matter, - - -	37.30
Ash, - - -	2.14

with the

REPORT

OF THE PROGRESS OF THE

GEOLOGICAL SURVEY

OF THE

STATE OF VIRGINIA

FOR THE

YEAR 1840.

BY WILLIAM B. ROGERS,

Professor of Natural Philosophy in the University of Virginia.

RICHMOND:

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1841.

Office of the Board of Public Works,
3d February 1841.

Sir,

I herewith transmit the annual report of the geologist of the state for the past year, which you will please lay before the house of delegates.

This report relates chiefly to the marl region between the Potomac and Rappahannock rivers, the northern district east of the Blue Ridge, and the great western coal region.

THOMAS W. GILMER.

To the Speaker of the House of Delegates.

REPORT.

In compliance with the law requiring me annually to present an account of the progress of the geological survey of the state, I beg leave to make the following report:

CHAPTER I.

OPERATIONS AND PRESENT CONDITION OF THE SURVEY.

SECTION I.

ORGANIZATION OF THE CORPS, AND PLAN OF OPERATIONS DURING THE PAST SEASON.

As the board is aware, the resignation of Professor *James B. Rogers* and *Charles B. Hayden*, who had been able and efficient members of the geological corps, from an early period of the survey, occasioned some delay in carrying into execution the entire plan of operations projected for the season. As soon, however, as the time for field duties arrived, the remaining members of the corps, *Dr. Boyd*, *Mr. Briggs* and *Mr. Slade*, repaired to the districts assigned them, and the vacancies above referred to having at length been supplied, by the appointment of *Mr. Samuel Lewis* and *Mr. Thomas S. Ridgway*, these gentlemen, also, as soon as practicable, entered upon their allotted duties.

In continuation of the explorations in which they had been engaged during the preceding season, *Messrs. Boyd*, *Briggs* and *Slade* were directed to pursue their enquiries in the unexplored portions of the great geological sub-divisions of the state in which they had previously been occupied, and in which their labours could be most beneficially employed.

Accordingly, *Dr. Boyd* entered upon a detailed examination of that sub-division of the district lying between the Blue Ridge and the western boundary of the marl region, which extends from the James river and a line passing through *Albemarle* county, to the Potomac; embracing a wide extent of primary and metamorphic rocks, an important portion of the formation designated in my last year's report as the middle secondary, and the narrow, though important, belt of still more recent sedimentary rocks, lying adjacent to the western limits of the marl, for most of the distance between the James river and the Potomac.

Guided by the knowledge of the more marked geological features of this region, already acquired by observations of my own, during a previous season, *Dr. Boyd* proceeded, at once, to trace the various important belts of rock occupying this extensive area, with the view of defining them accurately on the map, noting carefully the numerous detached beds of limestone occurring in a prolonged zone towards its western boundary, the ores of iron and other useful minerals, met with at various points, and connecting with all these local observations and longitudinal tracings, a series of accurate sections extending entirely across the region, in nearly equidistant parallels from its eastern margin to the summit of the Blue Ridge.

With the view of completing the exploration of that portion of the corresponding district south of the James river, to which the minute researches of preceding seasons had not been extended, *Mr. Samuel Lewis* was directed to pursue a course of examinations similar to those of *Dr. Boyd*, in the district lying between the James river and the *Carolina* border, and between the western boundary of the marl and the margin of the district previously explored. Besides making numerous lines of section, and intervening observations relating to the primary rocks occupying by far the larger portion of this area, he was instructed to complete the tracings formerly begun, of the coal basins lying in *Chesterfield*, *Powhatan*, *Henrico* and *Goochland* counties, so as to determine, with as much accuracy as our means of research permit, the irregular margin of primary by which they are enclosed, and to ascertain whether similar coal bearing strata recur at other places in the district under his charge.

To *Mr. Briggs* was committed the task of continuing the explorations begun by him during the preceding season, in the great western coal region of the state, by prolonging his observations on the Ohio, as far as the *Kentucky* line, at the mouth of Big Sandy, by carrying several important sections entirely or partially across the northwest portion of this region, among which was a preliminary line of observations along the Little Kanawha, and by a minute exploration of the valley of the Monongahela, comprehending the wide tract between the western flank of Laurel Hill, and the line along which the upper coal measures, and the important accompanying rocks, disappear beneath the level of the streams.

In connection with these extensive and minute enquiries, chiefly conducted in the northwestern portion of the state, a series of measurements and other observations, were directed to be made by *Mr. Ridgway*, from the falls of the Great Kanawha to Point Pleasant, with the view of completing the data for an accurate section along this line, and to this gentleman the further duty was assigned, of making preliminary explorations on the Coal, Guyandotte and Sandy rivers, so as to embrace the general features of that portion of the great western coal region, lying between the Kanawha river and the *Kentucky* line.

To *Mr. Slade* was assigned the duty of continuing the revision of certain portions of the Appalachian belts, in the district included between the western slope of the Blue Ridge, and the eastern boundary of the great coal basin of the west; imparting greater accuracy to

sections previously formed, constructing others illustrative of new lines of observation, and marking out the boundaries of some of the Appalachian groups of strata with more minuteness than had been previously attained, associating with the general tracings of the formations investigated, an examination of all the important localities of ores or other minerals included in them, and not previously made the subject of special enquiry.

In prosecuting the plan of operations contemplated in the above allotment of duties, to the several members of the corps, the amount of labour performed, and the progress made towards the completion of the survey, though entirely satisfactory, has fallen short in some portions of the field, of the anticipations expressed in my last year's report. This result, in part occasioned by the unavoidable delay in filling the vacancies which occurred in the corps early in the season, and by the time required by the newly appointed assistants to become familiar with the duties specially entrusted to them, was in a still greater degree the consequence of the protracted indisposition of *Dr. Boyd*, which, after causing frequent temporary suspensions of his labours, compelled him to withdraw entirely from active duties early in September, and in a few days after his arrival at the University, terminated in his much regretted death.

The board have long been aware of the zeal, knowledge and fidelity with which this gentleman uniformly executed his share of the labours of the survey, as well in active exploration, as in the selection and arrangement of specimens towards the formation of the public cabinet; nor do they need to be informed of the great value of his skill as a mineralogist, as well as a geological observer in the detailed examination of the widely extended primary region, in which for the last three years, he has been almost exclusively employed. Of his amiability of heart, and his general merits as a cultivator of those branches of science to which he was devoted, it would be inappropriate here to speak. It will suffice, while adverting to these and other engaging traits of his character, briefly to record an expression of our deep regret for the loss of his companionship and services in the corps, and of our sincere respect for his memory as a gentleman and a lover of natural science.

Since the close of our operations in the field, the chemical and graphical departments of the survey have as usual occupied a portion of the attention of myself and assistants, and will continue to receive a just share of our time and labours until the period for resuming field duties shall arrive.

The task enjoined upon each of my assistants, of drawing up detailed reports of their observations during the season of active labour, in general, giving them full employment until the winter is far advanced, and my own report calling for much additional labour in consequence of the imperfect shape of materials from which, at this period, I am compelled to frame it, the chemical and other collateral departments of our labours cannot be brought into full activity until a later period, and as a consequence of this, only a small portion of the details relating to these departments, and having immediate refer-

ence to the subjects treated of in the annual report, are in a state of sufficient forwardness for publication.

Before drawing to a close this general sketch of our operations, completed and in progress, it is proper to add, that continuing the employment of the thermometer as a means of determining heights, we have during the past season been enabled to make numerous useful measurements in various parts of the Blue Ridge, some of the parallel mountains lying west of it in the Appalachian belt, as well as of the lofty hills bordering on the Kanawha and Ohio rivers. These, and the measurements made in the two preceding years, are already sufficiently numerous to contribute important aid towards determining, with comparative accuracy, a highly interesting feature in the topography of the more rugged portions of the state, and at the same time to facilitate some of the most difficult explorations we are called upon to make.

By greatly multiplying the observations of this nature, as it is my wish to do, during the coming season, a most important accession will be made to our knowledge of the physical configuration of our territory, and while in this way the means will be furnished of representing accurately the results of our labours in sections and on the map, data will be afforded of no small value to future engineering enterprises in various quarters of the state, and of much general interest, as elucidating an important element in its geography.

Reserving these and other topographical details for my final report, I may be allowed to mention, in illustration of the general interest of the class of observations now in view, that by their means we have recently confirmed the conjectural opinion, prevailing throughout the southwestern quarter of the state, as to the altitude of the lofty peaks which form the prolongation of the great chain lying between *North Carolina* and *Tennessee.*

The elevation of the Balsam and White Top mountains, situated in the southwest angle of *Grayson* county, above the level of the South fork of Holston, near the state line, has been found of such amount as, when increased by the known elevation of the level thus referred to, to place the summits of these peaks at an altitude of upwards of 5000 feet above the level of the sea. This elevation, exceeding by about 1000 feet, the height usually but I think erroneously assigned to the Peak of Otter, is, I believe, the greatest altitude yet satisfactorily ascertained in *Virginia*, or indeed in any of the middle and southern states, and may be considered as defining approximately, if not absolutely, the culminating point of the numerous chains of mountains by which they are traversed.

SECTION II.

COMPLETION OF THE SURVEY.

Notwithstanding the delay and partial suspension of our operations in some parts of the state during the past season, I am happy still to have it in my power to say, that I look with confidence to the com-

pletion of our explorations and revisionary labours in the field, by the termination of the next campaign.

The districts remaining to be explored, are already well understood as to their marked geological features, and will present no impediments to enquiry for which we are not fully prepared, or which are likely to retard the rapid progress of our work. In order to complete our knowledge of all that portion of the state lying to the east of the Blue Ridge, it will be necessary to make additional researches in the primary region north of the James river, together with some further observations in the western portion of the Tertiary marl region, between the Pamunkey and Rappahannock rivers, as well as a general exploration of *Accomack* and *Northampton* counties. With regard to the western division of the state, I have little reason to doubt that, by continuing our revisionary work and measurements in the mountainous belt of the Appalachian formations, and including the examination of that portion of *Randolph* county which has not yet been examined, and by employing an adequate force in those parts of the great western coal region where our explorations are either incomplete, or have not yet been commenced, we shall, by the termination of the season, have attained such a knowledge of every part of this vast territory, as will enable me to give accurate descriptions and delineations of its geology, and to present a complete and finished picture of its numerous and valuable mineral resources.

There will then only remain to be executed such further duties connected with the preparation of the sections and maps to accompany the final report, and with the analysis and arrangement of specimens for the cabinet, as may be found necessary for the completion of these departments of the survey. In the meantime, the final report for which I am already preparing, and with which I propose to occupy myself during the progress as well as after the close of these auxiliary labours, will be advanced with all the rapidity compatible with the magnitude of the task of framing such a work in a manner suitable to the importance and dignity of the enterprise of which it is to detail the results, and to constitute the crowning labour.

In thus adverting to the approaching termination of my arduous tasks, I may be allowed to express the heartfelt satisfaction with which I contemplate this wished-for result, and the real pleasure I experience in the anticipation of bringing the enterprise to a close at as early a period, and with as small an expense to the state, as in my early calculations I pronounced adequate for the purpose.

In proof of the punctuality and economy here referred to, I may be permitted to remind the board, that when in the report of 1836, I urged the expediency of augmenting the annual appropriation from five to eight thousand dollars, I expressed the conviction, that with the force at that time at command, it would not be practicable to bring the survey to a termination in less than twelve years; while with the enlarged means then solicited, the work might be completed in one half the time, and at an expense which would probably fall short of fifty thousand dollars.

As yet, less than five years have elapsed since the organization of the corps under the enlarged appropriation, and the expenditure, including that for the first year of the regular survey, has scarcely amounted to 36,000 dollars.

SECTION III.

SUBJECTS AND PLAN OF THE PRESENT REPORT.

In conformity with the plan adopted in the report of last year, I purpose, on the present occasion, confining myself to a sketch of such districts of the state as have been most completely explored, and as from their simple geological features, admit most readily of being illustrated without the aid of sections or other drawings, adding subsequently a brief account of our operations in other regions still under investigation, and closing as usual with a variety of chemical details.

In fulfilling this design, I deem it unnecessary, and indeed inexpedient, to aim at fullness of detail, even to the extent attempted in my last year's report, as from the advanced stage of our labours, the final report, comprehending all the results, with the requisite accompaniment of numerous graphical illustrations, will soon be in progress of preparation for the public eye. Indeed, were it not that an annual sketch of the progress of the survey is required by the enactment providing for its execution, I would feel myself authorized to dispense with any further partial reports of this nature, and would prefer devoting the time and labour they demand, to the advancement of the researches remaining to be performed, and the preparation of materials for the final report.

In view of these considerations, the board will, I have no doubt, unite with me in admitting the propriety of restricting my present report within comparatively narrow limits.

I shall accordingly, therefore, proceed to give a brief sketch of the geology of the following districts:

1. That portion of the marl region situated between the Potomac and Rappahannock rivers.
2. The narrow belt occupied by the upper secondary sandstones and the marls extending along the eastern margin of the primary rocks from *Petersburg* to the Potomac.
3. Parts of the northern primary district lying between the Blue Ridge and the belt just mentioned, and between the range of *Albemarle*, *Fluvanna* and *Goochland* counties and the Potomac, including an important portion of the interrupted belt of the middle secondary formation.
4. Portions of the great western coal field, including particularly a part of the Monongahela valley and the valley of the Ohio.

In addition to these subjects of more specific illustration, I shall briefly describe the course of our explorations in the eastern portion of the primary district lying south of the James river, and in the wide region of our western coal field.

As the various labours executed in the Appalachian region during the past season, bear immediate reference to sections, measurements, and minute tracings on the map, and from the complexity of structure and topography to which they relate, would not admit of being satisfactorily described without the aid of numerous drawings, I deem it expedient to omit any prolonged description of them at present, and shall, as regards this region, confine myself to the report of some chemical details of interest, relating to its rocks and ores.

CHAPTER II.

TERTIARY MARL REGION BETWEEN THE POTOMAC AND RAPPAHANNOCK RIVERS.

SECTION I.

EXTENT AND TOPOGRAPHICAL FEATURES.

The portion of the state referred to under this head, embraces the counties of *Lancaster*, *Northumberland*, *Richmond*, *Westmoreland* and *King George*, together with the eastern part of *Stafford* county; thus including the district usually denominated the *Northern Neck*, and extending some distance beyond it to the west.

This area forms the northern portion of the tertiary region of *Virginia*, presenting extensive deposits of each of the two subordinate divisions of the tertiary formation, described in former reports, as occupying the tide water districts of the state. The more recent of these subordinate formations, the Meiocene, or middle Tertiary, extends from near the bay shore, westward, over the larger portion of the peninsula; while the older, or Eocene deposit, with an occasional capping of the former, occupies the remaining area on the west.

The precise boundaries of these formations will be hereafter described.

TOPOGRAPHICAL FEATURES.

The general aspect of the peninsula, and more especially of the four eastern counties, is that of a nearly level plane, maintaining an average elevation of from sixty to seventy feet above the tide. This plane, gently furrowed by numerous ravines, subordinate to the creeks and inlets indenting the peninsula, frequently subsides to a lower level, in approaching the rivers on either side. The wide bench thus formed, sometimes extends in a direction parallel to the river for a distance of several miles, presenting an unvarying uniformity of elevation, and reaching nearly to the water's edge. A third, and lower plane, frequently intervenes between the river bank and the table land above described, but in many cases, this terraced configuration of the surface is not observed, and the high and precipitous cliffs

which rise very near the water's edge, retain the general level of the inland portion of the peninsula. Although the usual elevation of this district is such as above described, at several points a far higher level is attained. The ridge which forms the water-shed of the streams flowing into the Potomac and Rappahannock, approaching very near to the former, constitutes, in some places, the river bank. At these points, it attains an unusual elevation, towering, as at *Stratford* and *Chantilly*, to a height of about one hundred feet above the water's edge, and affording, from its summit, an extensive and enchanting view of the noble river which laves its base, of the cultivated farms around, and of the cliffs on the opposite or *Maryland* side of the Potomac. At '*Sprise Hill*, about four and a half miles from Smith's Point, the ridge bends round to the south, and continues for some distance in a direction across the peninsula, preserving an elevation of about sixty feet. Its declivity on the east forms an abrupt termination of the higher level of the neck, between which and the bay is an extensive flat, of from two to four miles in width, rarely rising beyond the height of ten feet above the level of the tide, and in some places so low, as to be occasionally overflowed.

The western portion of the peninsula, though still in the main presenting a similar uniformity of surface, is somewhat more abruptly furrowed. This inequality increasing as we proceed farther to the west, becomes quite conspicuous at the Paspitansy hills, in *King George*, and in the neighbouring parts of *Stafford* county, adjacent to the line of secondary sandstone, which forms the western limit of the Tertiary formation. The material forming the superficial strata in the lower portion of the peninsula, is usually a mixture of sand and clay, in a state of minute subdivision, and more or less tinged with the oxide of iron. Sometimes this is intermixed with small gravel, of a ferruginous appearance, but it rarely contains pebbles or boulders of any notable dimensions. The diluvial matter assumes a coarser texture, as we proceed westward, presenting, when denuding forces have not removed the superficial beds, alternate strata of sand and pebbles, the the latter varying from a half inch to several inches in diameter. In many places, these boulders, derived in great part from the neighbouring beds of sandstone, are strewed profusely over the surface, and, together with the superficial layers of white and siliceous sand, render the soils of the higher portions of this district comparatively unproductive, while upon the lower levels, contiguous to the large rivers, or their tributaries, the beds of marl and their associated sands and clays, mingling their fertilizing materials with the soil, have contributed to impart to it a far higher agricultural value.

SECTION II.

OF THE LIMITS OF THE MEIOCENE AND EOCENE DISTRICTS OF THE PENINSULA.

Bounded on the west by the secondary sandstone before referred to, the Eocene formation extends eastward for some distance down the

neck, until at length, with a very gentle eastern dip, it disappears below the level of the tide. The most eastern points in which it continues visible, are here regarded as forming the boundary of the formation towards the east, and the district included between a line traced through these points, and its boundary to the west, is, for convenience sake, designated as the Eocene district, although, at some places within its confines, as in other parts of the marl region, beds of Meiocene occur overlying the Eocene.

In tracing the boundary of the Eocene and Meiocene marls, as exposed in the neck, several localities, marking the eastern termination of the former deposit, were carefully inspected in the anticipation of discovering beds of Meiocene shells above them, or immediately beyond them to the east. It was found, however, that strata of clay, lying adjacent to the Eocene on this side, occupied an interval in which fossils of neither of these formations could be distinctly found; and that still further on, the beds of the Meiocene came in view. This intervening tract, as seen upon Potomac and Rappahannock, is flat and low. Without, then, pretending to an exact delineation of the boundary in question, which, from the nature of the case, would be impracticable, it will be sufficient to consider it as coincident with a right line, connecting the mouth of Chingoteague creek on the Rappahannock, with Mathias's Point upon the Potomac.

A brief account of the character and situation of the strata, as observed at these two points, will serve to illustrate the propriety of fixing upon them as its termination.

To the west of the mouth of Chingoteague creek, for a distance of more than half a mile, the north bank of the Rappahannock has an average height of about fifteen feet above the river. At its upper end, this bank consists of a stratum of the green sand marl, extending to the height of twelve feet above the water line, upon which reposes a layer of diluvial sand and clay, about three feet in thickness. In approaching the creek, the level of the marl stratum is observed steadily to decline, while the thickness of the incumbent bed augments, until at a point within two hundred yards of the mouth of the creek, the former entirely disappears below the level of the river. At this point, the diluvial capping is about fourteen feet in thickness, consisting of a layer of sand and pebbles about seven feet thick, resting upon a stratum of whitish clay, which reaches to the water line.

The Eocene character of these subjacent beds is unequivocally marked. At the base of the bank a dark greenish layer presents itself, rising to the height of five or six feet, containing numerous impressions of the Eocene Carditas, and other shells, of a brownish colour. Over this is a layer of a lighter hue, containing bands of white calcareous matter, obviously the remains of shells.

To the east of Chingoteague creek, the bank preserves its former height for about three-fourths of a mile; after this it becomes much depressed, and continues to be low for some distance down the river. Here no trace of fossils of either the Eocene or Meiocene period could be discovered, the bank consisting exclusively of diluvial sand and gravel. But still farther down the river, beds of the latter are

observed, and these continue, at intervals, to near the extremity of the peninsula.

An equally marked termination of the Eocene is presented in the neighbourhood of Mathias's Point, on the Potomac. At *Woodstock*, about one third of a mile above the point, the cliffs rise to the height of from forty to fifty feet, exhibiting an exposure of the Eocene strata reaching to a distance of nearly twenty-five feet above the surface of the river. The lower bed, about eight or nine feet thick, is rich in the fossils characteristic of the Eocene; but the layer, incumbent on this, though filled with ferruginous impressions of shells, retains none of the shells in an unchanged condition. The bed of reddish clay which forms the upper portion of the bank, is separated from the strata just described, by a thin band of ferruginous gravel and sandstone, such as is frequently seen occupying a similar position on the Pamunkey, and in other localities.

Above this place, on the adjacent estate called "Borodino," (the residence of *Mr. Parke*) the banks, after sinking to a level with the flats, again rise with some abruptness, to an elevation of from forty to sixty feet. The lower stratum of the marl, containing shells in considerable number, is here but little raised above the level of the water. A layer deeply tinged with green sand, and blotched with oxide of iron, rests on this to the height of from four to five feet. Another, but not fossiliferous bed, belonging to the same series, reposes upon the latter, but the piles of fallen earth, at present, preclude an accurate examination of its nature and extent. Still further westward, at "Albion," the estate of *Mr. Mason*, the fossiliferous Eocene strata vary from four to seven feet in height above the river, and are overlaid by heavy beds of whitish and mottled clay. Similar strata recur, at intervals, in ascending the river, rising to greater elevations, and presenting a greater abundance and variety of fossils as we proceed.

Below *Woodstock*, the banks gradually decline, and on the side of a little creek or gut between this and Mathias's Point, the Eocene strata entirely disappear. To the east of this creek, and at the point, the banks rise to twenty or twenty-five feet, and consist of yellowish and reddish clays, containing no trace of the green sand or fossils of the Eocene. Still further down, the cliffs are replaced by a low and retiring shore, beyond which the beds of Meiocene marl first come in view.

It is obvious from these details, that the eastern limit of the Eocene is marked on both rivers by the occurrence of a region of like geological and topographical features, immediately east of it, and by great similarity in the arrangement and composition of the contiguous strata. As on the James and Pamunkey rivers, as well as in the district of which we are now treating, the Eocene is skirted on the east by a level and comparatively low district, comprising only beds of sand and clay, destitute of fossils, it would seem a probable conclusion that these barren strata mark the period of disturbance which terminated the epoch of the Eocene deposits, a period attended with such important changes in the condition of the neighbouring seas, as to destroy all, or nearly all, the species of shell fish then inhabiting

them, and to adapt their waters to that multitude of new species which were brought to light in the succeeding epoch of the Meiocene.

Between the two points thus fixed upon as the extremities of the eastern boundary of the Eocene in the neck, several intermediate localities have been marked, but from the obscurity of the exposures, no very certain indication could be derived as to the precise figure of the boundary line in the intervening space. There is little doubt, however, that it will be found to depart but in a very slight degree from the right line connecting the two points above described.

The western boundary of the Eocene remains next to be described. In drawing the line of demarcation here, as in the former case, a few well-determined points are relied upon for fixing its general direction, and the intervening irregularities are not attempted to be laid down. Indeed, the absence of any satisfactory exposures of the strata, throughout a distance, sometimes of several miles, renders this the only method of proceeding at present practicable.

The guiding points in fixing the western limits of the Eocene in the peninsula, are:

1st. The mouth of the Massaponax river, in *Spottsylvania* county.

2d. A point a little east of Gray's mill, on Little Falls run, about half a mile above its mouth, and three miles southeast from *Fredericksburg*, in *Stafford* county.

3d. The church on Potomac creek, a little above which the freestone is largely exposed.

4th. A point a little below Brook's mill, on Accakeek creek.

5th. A point on Acquia creek, about one mile below the mouth of Austin's run.

6th. The mouth of Still House branch, on Meadow branch, and a point on the Potomac about one mile above the mouth of the latter.

An inflected line passing through these points, will present a close approach to the western boundary of the Eocene in this part of the state. At the same time, in certain local instances, the marl is observed in positions somewhat west of the margin thus delineated, existing either as an outlying patch in the midst of the adjoining formation, as in the small tract lying a little southeast of *Stafford* courthouse, or as portions of a narrow tongue entering westward of the main boundary of the marl, as in the case of the Eocene deposits observed at Thrashly's farm, and within a mile of *Fredericksburg*.

On the west side of the mouth of Massaponax, the freestone, which constitutes so valuable and interesting a feature in the geology of this district, terminates; and at a short distance below, Eocene strata come distinctly into view. Where the main road leading down the Rappahannock crosses the Massaponax, the greenish yellow bed, which frequently forms the highest stratum of the Eocene, may be plainly discerned in the hill side, its clayey texture turning off the water, which makes its escape along its upper surface.

On Snow creek, on the edge of *Spottsylvania* county, and less than a mile to the east of Massaponax, several extensive exposures of the Eocene occur. Near the point at which the road before mentioned crosses the creek, a bank of from thirty to forty feet in height exhibits the following series:

1st. A dark bluish green stratum, containing a little sulphate of lime, a considerable portion of green sand, and a great many shells, among which are Eocene cardita, Cytherea and Turritella.

2d. Stratum of greenish yellow, and somewhat micaceous clay, containing some sulphate of lime, and a little sulphate of iron, or copperas.

3d. Stratum of a yellowish brown mixture of clay and sand, with ferruginous markings, indicating the former places of shells. This contains a small amount of sulphate of lime.

4th. An upper bed of diluvial sand and gravel.

On the same stream, nearer the river, and at the base of the first low grounds, another exposure occurs, which, from the peculiar condition of the fossils it contains, merits a description in this place. The strata are as follows:

1st. A layer, consisting of common and green sand, the latter in remarkably large grains, and amounting to more than twenty per cent. of the whole. A striking feature in this stratum is the immense number of fossils, principally Cytherea ovata, and Turritella Mortoni, which it contains in the modified condition before described. The shelly matter has almost entirely disappeared, and its place is now occupied by oxide of iron, of a deep brown colour, presenting the most perfect casts, both of the interior and exterior of the shells. This bed contains a notable proportion of green sand, a little Mica, and some sulphate of lime and of iron. Its thickness is about eight feet.

2d. A stratum of yellowish white sand, variegated with numerous bright yellow blotches, faintly representing the figures of the shells which they have replaced. These blotches are principally composed of oxide of iron. The chief material of this bed is common siliceous sand, containing a few scattered granules of green sand. Its thickness is about twenty feet.

3d. Diluvium, containing coarse gravel, and some large pebbles.

On the Accakeek, near *Mr. Brook's*, the Eocene and Sandstone are seen at very contiguous points, both presenting exposures of considerable extent. The marl here consists chiefly of shells imbedded in a dark olive brown clay, containing a portion of green sand. The shells are chiefly Cytherea lenticularis and Ostrea sellæformis, or the Saddle Oyster, with a few Venericardia ascia. At *Mrs. Rolls's* on Acquia creek, about two miles below the mouth of Austin's run, the marl is finely exposed in an abrupt cliff. Here fine specimens of fossils, comprehending Turritella, Cytherea, Crassatella and Ostrea may be procured. The material in which they are imbedded, is a friable mixture of sand and clay, of a light yellowish brown colour, blended with green sand in granules of unusually large size.

In thus drawing an outline of what may be termed the western coast of the Eocene formation, as already remarked, the peculiar irregularities observed at several points in the actual boundary, will occasion considerable discrepancies between it and the line above described.

Besides such flexures as may have originally existed in this line at the period of the deposition of the Eocene, great additional irregula-

rities must have been produced by the destructive agencies which subsequently operated. The region in which the Sandstone and Eocene formations are brought together, is marked by the effects of violent diluvial action. Coarse gravel, pebbles and boulders bestrew the surface, and mingle to considerable depths with the sandy strata usually found upon the heights. Deep and precipitous ravines, connected with the valleys of the creeks leading into the Potomac, attest the energy and extent of the aqueous forces once operating over this region, while the confused mixture of materials, by which the usual upper stratum of the Eocene is often seen to be replaced, indicates the power of the denuding and transporting agencies to which that formation must at one time have been exposed. It is thus that many places within the general confines of the Eocene, bared of their former covering, now merely expose the underlying beds of freestone, while at other points, not immediately in the line of the violent action of the diluvial wave or current, the incumbent beds of marl remain in place.

Moreover, there is reason to believe that the sandstone is spread out towards the east, below the Eocene strata, and that its depth alone conceals it generally from the view. Where, therefore, in consequence of some local irregularity of its surface, it was less deeply buried, we might naturally expect, even at some distance within the confines of the Eocene to see its upper stratum exposed to day.

SECTION III.

ARRANGEMENT AND COMPOSITION OF THE MEIOCENE STRATA OF THE PENINSULA.

The strata composing the Meiocene in this portion of the state, are in general analogous in arrangement and materials, to those of the same formation, in the peninsula of the James and York rivers, as described in my first report, and indeed preserve a close resemblance to those of the region south of James river, systematically treated of in the report of last year.

The two interesting general facts of the occurrence of the bluish marls low down in the series, and the presence of a thin band of ferruginous rock or clay on the top of the marl, and between it and the diluvial strata, are not less distinctly observable here than in the regions formerly referred to. Indeed, so uniform is this position of the band of iron rock, in regard to the beds of marl, that the discovery of this material, at any point, would furnish strong grounds for believing that the fossiliferous strata existed at some depth beneath.

As another feature of correspondence between this and the districts previously described, I may mention the occurrence of the fragmentary marl along the eastern boundary of the Meiocene terrace, where it subsides abruptly into the low flats immediately adjoining the bay shore. On the Curratoman river, and at other points along this escarpment, the rocky marl, consisting of water-worn fragments of shells, more or less firmly cemented together, is in all respects analogous to that described in previous reports, as forming the material of

the edge of the Meiocene terrace between the Rappahannock and James rivers, and for some distance southwards of the latter, so that we may regard this curious demarcation of one of our ancient coast lines as continuous from the Potomac river to near the *Carolina* border.

In general, the blue marl is observed to be the richest in fossils, and is hence found most available in agriculture. In many places, however, especially towards the eastern termination of the peninsula, the shells occur in sand and clay of various shades of yellow and brown, in sufficient proportions to form highly valuable marls.

In addition to the fragmentary rock, above referred to, consisting of broken shells, cemented by carbonate of lime, sometimes partially crystallized, the white, pulverulent and chalk marls, are found in extensive beds on Curratoman river and Carter's creek, west of the termination of the higher level of the neck.

In general, the upper beds of the Meiocene, in this district, are destitute of fossils, though full of their casts and impressions. These strata, consisting, for the most part, of light coloured sandy clays, frequently of great depth, are distinguished by a sulphureous smell, and an acid and somewhat styptic flavour. They rarely contain any considerable amount of carbonate of lime, presenting, in its stead, variable, and sometimes valuable proportions of the sulphate, together with sulphate of iron, sulphate of alumina, free sulphuric acid, sulphur, and sometimes even an appreciable quantity of sulphate of magnesia.

The acidity of these clays is often sufficient to make a pungent impression on the tongue, and their sulphur is distinctly recognized by the characteristic odour they exhale, especially when gently warmed.

In many localities, the Gypsum occurs in crystals of sufficient magnitude to be readily separated by the fingers, and sometimes even in the attractive form of transparent Selenite; but this more usual condition, is that of delicate silken crystals distributed through the mass, and visible only upon close and attentive inspection. The Sulphates of iron and Alumina, are occasionally observed in the form of an efflorescence, upon the surface of the strata, and the Gypsum likewise presents itself, under similar circumstances, as a white incrustation.

Minute silvery scales of Mica are met with in nearly every stratum, but abound most in those of a bluish or greenish tinge.

The fossil impressions contained in these beds are, in general, beautifully distinct, and appertain to all the species of shells which are found in perfect condition in the subjacent strata. In some cases the overlying band of iron stone is not less richly fraught with them than the layers beneath, and from its hardness and insolubility, has preserved the most delicate markings of the shells in all their original sharpness. In many localities, the impressions of the fossils in the clay or sand, are beautifully bronzed by a thin film of oxide of iron, which has taken the place of the material of the shell; but in others a *vacancy seems* to exist in the space originally occupied by the calcareous *matter*, so that the interior casts of the fossils, formed of the

general substance of the bed, may often be extracted in great numbers in a perfect condition.

In the blue marl, as well as other strata containing fossils, in the neck, there is often present a notable portion of green sand, and at some localities of the Meiocene, this material is found mingled pretty largely with common sand and clay, in strata in which no fossils can be found. Besides the overlying band of ferruginous rock before described, there occurs, in some places in the neck, another similar stratum, nearly on the top of the diluvium. This, of course, presents no marks of organic remains, and is generally but an aggregation of coarse gravel and sand, cemented by ferruginous matter.

SECTION IV.

DESCRIPTION OF SOME OF THE MORE INTERESTING LOCALITIES IN THE MEIOCENE DISTRICT OF THE PENINSULA.

To give clearer conceptions of the arrangement and character of the strata, of which a general sketch has just been presented, a detailed account of them, as exhibited at several of the more important localities in the neck, will now be introduced. Details of this description, whilst they furnish the scientific inquirer at a distance, with that precise information, in regard to the geological structure of the region, which he is chiefly interested to obtain, are not unattended with advantages of a more practical kind, by affording to all who are directly interested in the resources of a district, an easy mean of examining them for themselves.

Stratford and Chantilly Cliffs.

These noted cliffs, situated in *Westmoreland* county, extend along the Potomac for several miles, on both sides of the mouth of Chantilly creek, rising, in some places, to an elevation of about one hundred feet, and in others subsiding to lower levels, or sinking, for a short space, into the ordinary river flats. At a point a little above the mouth of the creek, what are properly termed the Stratford cliffs, begin. Thence they continue up the Potomac, with but little interruption, for about four miles. For some distance from their lower termination, they present the following order of strata:

1. At the base, and extending to the height of from fifty to seventy feet, a stratum of blue sandy clay, containing impressions of shells of several different kinds, among which the Pecten Madisonius, Venus mercenaria, Venus cortinaria, and Mactra modicella, are the most frequent. Upon the surface of this clay, especially where it projects from the general cliff, a copious efflorescense of sulphate of iron is usually found, imparting a greenish yellow colour to the surface. At other more retiring parts of the cliff, a white, and somewhat granular coating of sulphate of lime, is equally abundant, and small silken crystals of this substance are generally disseminated through the materials of the stratum. On the surface of this bed, delicate crystals

of sulphate of magnesia may likewise be discerned. This stratum is overlaid by a band of indurated ferruginous clay, approaching to the hardness of rock, and filled with a material closely resembling pipe-ore. This is about two feet thick. Next above is a stratum consisting, alternately, of sand and ferruginous mottled clay, extending to a height of about forty feet; and lastly, is a layer of diluvial gravel, covered with a shallow soil.

Farther up the river the cliffs attain a greater elevation, being, in some places, about one hundred feet in height. Here the same strata occur, and in the same order as before. Proceeding still higher up the river, a band of shells makes its appearance upon the face of the cliff, at a height of about fifteen feet above the water. This rises, as we ascend the river, with a gentle inclination, until at its northern extremity it is fifty or sixty feet above the beach. The width of this band is about five feet, and its length, though not without occasional interruptions, about one and a half miles.

The material of this stratum is a bluish sandy clay, very similar to that before described, but containing no appreciable amount of the various sulphates observed to be present in the former. The shells are very numerous and perfect. Among them are vast numbers of the Perna maxillata of small size, as well as Turritella plebeia, Mactra modicella, &c., with an occasional Arca idonea, and other larger shells. Above this bed is a heavy stratum of clay, of a mottled appearance, and higher still, and distant about twenty feet from the former, a second fossiliferous layer of a lighter colour, and containing fewer shells. Among the various substances found in the strata of these cliffs, especially towards the lower extremity, are to be enumerated distinct and beautifully compact lignite and fibrous carbonate of lime. The latter is found in the interstices of a yellowish clay, forming the stratum next beneath the diluvium, and is sometimes in sufficient quantity to render the clay quite calcareous.

An average specimen of the blue marl, from the lower of the two strata just described, yielded, in the one hundred grains, forty-four and three-tenths grains of carbonate of lime; from the upper only twenty-one grains.

The Chantilly cliffs, situated below the mouth of the creek of the same name, adjoining the ancient residence of *Richard Henry Lee*, and about two miles further down the river than those of Stratford, may be regarded as a continuation of the former, having the same average elevation, and being composed of very similar materials. At this point, however, the fossiliferous stratum has much greater thickness, sometimes reaching from the water's edge to a height of nearly twenty-five feet. A less proportion of the Perna is presented in this bed, which principally consists of Mactras, and other small bivalves, together with several species of Pectens. The beach is strewed with fragments of ferruginous sandstone, which have fallen from the upper portion of the cliff, where a band of this material overlies the shelly strata of the Meiocene. These masses exhibit the impressions of Pectens and other shells, beautifully clear and sharp.

An interesting illustration of the fertilizing properties of some of the materials composing the Stratford and Chantilly cliffs, is deserving of mention in this place. Zones of vegetation, consisting of clover, together with scattered locust trees, may be observed at the proper season, extending to a great distance along the face of the cliffs, marking distinctly the limits of the marl or gypseous clay, and rarely encroaching upon the other strata. Even where the surface is almost vertical, this beautiful drapery is retained.

Bank of the Potomac below the mouth of Lower Machodoc River, in Westmoreland County.

At Cole's Point, situated on the south side of the mouth of the Lower Machodoc, commences a low bank, which is prolonged for about one and a half miles down the river, at a pretty uniform elevation of fourteen feet. A few paces below the point, the following strata occur:

1. A layer two feet thick, consisting of a bright yellow mixture of sand and clay, abounding in shells of various kinds, among which are, Perna maxillata, Ostrea compressirostra, Venus mercenaria, V. cortinaria, V. paphia, Isocardia fraterna, Pecten Madisonius, P. Jeffersonius, Pectunculus pulvinatus, Corbula inequale and Turritella variabilis.
2. Next a layer six feet thick, composed of mottled ferruginous sand with a small admixture of clay, containing no shells, but abundant markings, as if shells had once been present in great numbers.
3. A band of iron sandstone three inches thick; and
4. A dark mould, extending to the top.

In proceeding down the Potomac, the yellow marl is seen gradually rising higher in the bank. A stratum of blue marl lying beneath it next comes in view, and this continues along the base of the bank, extending some distance out upon the beach, until the shore sinks into a low sandy flat at Ragged Point.

The Rappahannock cliffs in *Richmond* county, nearly opposite to *Westmoreland* courthouse, extend along the river for about four miles at an average elevation of from forty to sixty feet. Throughout this long range of strata, but little variety is presented. Beds of sandy clay, of various shades of yellow, brown and greenish blue, extend from the water's edge to within a few feet of the top of the bank. In general, the first thirty feet consist of a dark greenish blue mixture of sand and clay, above which is a layer, six feet thick, of similar material, of a brown colour; next, a band, of twelve inches, of a ferruginous aspect, and over all a stratum of light coloured flaky clay, coated with a yellowish and white incrustation of sulphate of lime. Fossils are rare in any of these beds, but multitudes of their casts and impressions may be found. These embrace a great variety of the smaller shells, some of them of species frequently met with. Spiculæ of gypsum are distributed in the body of the clay, and are particularly numerous upon the surface and in the hollow of the casts, which, in general, are painted over with the brown oxide of iron. In many

places sulphate of iron and sulphate of alumina effloresce upon the surface, and sulphur is distinctly indicated.

Irregular nodules of ferruginous clay are found imbedded in the other materials, presenting the curious feature of a crystalline nucleus, consisting of pure Selenite. In some portions of the cliff, these crystals are of considerable size, arranged in their usual star-like form, and so abundant as to suggest the utility of employing these clays in the agriculture of the neighbouring parts of the neck. An average specimen, taken from a part of the cliff where similar material was quite abundant, afforded by analysis, in the one hundred grains, ten grains of sulphate of lime.

Banks of the Rappahannock above the mouth of the Curratoman River, Lancaster County.

In proceeding down the river from the neighbourhood of Belmont, the residence of *Dr. Jones*, about eight miles above the mouth of Curratoman, the cliffs for some distance present heavy beds of clay and sand, overlaid by the ordinary diluvium, and resting upon a stratum of soft ferruginous sandstone, graduating into a sandy clay, and sometimes a yellowish sand, mottled with ferruginous spots.

Following these strata for a distance of one and a half miles, we meet with a rocky layer, consisting entirely of shells, converted into brown oxide of iron, situated at the base of the cliff. This continues in the same direction for a distance of one and a quarter miles. The following is the order of the strata composing the bank at a point near its eastern termination:

1. Beneath the base of the cliff, as it is exposed, and as underlying the beach sand, is a blue marl, containing numerous shells, and having a sensible amount of green sand. These shells are chiefly Perna, and different species of Venus, Natica, and Oliva.
2. Running along the base of the bank, the ferruginated, shelly rock above described, four feet in thickness, and containing the same fossils as the stratum beneath.
3. Five feet of sand, with ferruginous blotches and streaks.
4. Six feet of diluvium.

Below this, and within a short distance of the Curratoman, marl beds occur below the level of the flats, consisting chiefly of a peculiar variety of the Ostrea Virginica, of which a similar deposit exists on the opposite side of the Rappahannock. It is distinguished by the length and depth of the channel of the hinge in the one valve, and the large angular pivot-like protuberance in the other, as well as by the general elongated form of the shell.

Bank of the Rappahannock from near Cherry Point, Lancaster County.

At about one mile above Cherry Point, at *Mr. Palmer's*, the bank consists of the following strata:

1. Forming the base of the cliff, and extending up about three feet is a blue clay marl, containing a great many shells. This layer

reaches to some depth below, and extends out beneath the sand of the beach.

2. A bed of chocolate coloured clay, imbedding a vast number of the variety of Ostrea Virginica, previously described. This is three feet in thickness.

3. A bed of partially decomposed serpula, containing few other fossils, one foot thick.

4. A layer of ferruginous sandstone, in bands alternating with thin seams of sand. Three feet thick.

5. Ten feet of diluvium.

The above strata, in the order just described, continue down the river for the distance of half a mile, appearing to dip gently towards the bay. The marl is then lost for about two and one half miles, after which it reappears, at intervals, as far down as Musquito Point. Here the country becomes a sandy flat, and so continues to the bay shore. In the interval of two and a half miles, where no marl is seen, the cliffs, which are from twenty to thirty feet in height, consist at the base of blue clay, containing impressions of shells; above this of ferruginous sandstone, or of ferruginous sandy clay; the whole covered with a bed of diluvium.

Near the end of this line, a blackish, clayey substance rises into view from the base of the cliff, underlying the blue clay above mentioned. This gradually becomes more exposed upon the bank, until it attains the height of four feet, after which it slowly sinks, and is again lost. The marl now makes its appearance, consisting of a blue clay, with little sand, and multitudes of shells. This reaches along the bank for about four hundred yards, when it is succeeded by a shell rock, in which the shelly fragments are almost completely replaced by brown oxide of iron. This continues to near the end of the bank, which now subsides into the flat, extending from Musquito Point to Windmill Point, on the bay shore.

Locality one and a half miles east of Lancaster Courthouse—Mr. Benjamin Walker's.

This exposure, which is in a ravine on the ridge of the neck, presents the following strata:

1. A bed of blue marl, containing great numbers of shells, many of which are of the larger species. The depth of this stratum is not known.

2. A similar stratum of a rather lighter colour, and containing chiefly the small shells. Three feet thick.

3. A layer of ferruginous matter, abounding in the casts and impressions of shells. These casts are usually found in the interior of spheroidal nodules, or geodes of oxide of iron, and consists of this oxide replacing the shelly matter, and covered with a beautiful shining covering of the carbonate or velvet iron ore. This bed is four feet thick, and reaches to the surface.

Locality four miles Southwest from Northumberland Courthouse. Mr. George Booth's.

This exposure is in a hollow, about twenty-five feet below the level of the ridge. The strata are:

1. A layer of greenish blue marl, containing a notable amount of green sand, in spots and blotches, and sometimes almost unmixed with other materials. This stratum has been penetrated five or six feet, and is believed to extend to a much greater depth. The shells are in a state of remarkably perfect preservation, and present an unusual variety of species, belonging to the genera Venus, Pecten, Pectunculus, Mactra, Crassatella, Astarte, Ostrea, Corbula, Turritella, Oliva, Fissurella, and others. Their interior is filled chiefly with the green sand.
2. A layer of ferruginous sandstone; and
3. A stratum of diluvium.

Locality of Cockle-shell Branch, Northumberland County.

Here the strata are:

1. A bed of marl, consisting of common sand mixed with green sand, and containing a large number of shells.
2. A layer of a bright green, indurated sandy clay, approaching to the hardness of rock, and containing innumerable impressions of Venericardia granulata, Pectunculus pulvinatus, and P. subovatus, and other shells of rare delicacy and beauty, but entirely devoid of the shells themselves.
3. A bed of common sand, largely mixed with green sand.
4. A layer of sandy clay, with markings resembling shells.
5. Diluvium.

Locality two and a half miles above the mouth of Hull's Creek, Northumberland County.

1. At the base of the steep bank of the creek, and within a few inches of the water's edge, occurs a ledge of ferruginous rock, containing an immense number of shells, closely cemented together, as well as the casts of similar fossils. These are chiefly Perna max. Venus and Pecten. This ledge is two feet thick.
2. A stratum of yellowish sandy clay, of the same thickness, abounding in Perna max. in a very friable condition.
3. A light blue marbled clay, ten feet.
4. Coarse diluvium.

The foregoing detailed account of various localities in the neck, will, it is hoped, give a correct idea of the generally prevailing order and fossil contents of the Meiocene strata in this district, and at the same time exemplify the principal varieties presented in them, as regards the nature of the earthy materials, including the shells, or their casts, as well as the conditions of the fossils themselves.

Of the numerous other localities which have been minutely explored, embracing almost every exposure of the Meiocene in the peninsula, it is therefore needless to give any description in this place.

In the extensive area of flats, already described as reaching from the foot of the ridge, of which *'Sprise Hill* is the northern end, to the bay shore, beds of marl have hitherto been disclosed only at a few points. On the land of *W. Tomlin, esq.* near *Kilmarnock*, blue and yellow marls have been found in several places, a few feet beneath the general level of the flat, and it is particularly worthy of remark, that the fossils furnished by these shallow diggings, are those usually found in the Meiocene of the neck, such as Ostrea compressirostra, Pectunculus pulvinatus, and P. subovatus, Mactra modicella, &c. thus indicating the prolongation of the Meiocene strata to the very extremity of the peninsula.

SECTION V.

OF THE FOSSILS OF THE MEIOCENE MARL.

The shells enclosed in these strata are usually in good preservation, though generally so friable as readily to fall to pieces when spread upon the ground. They are commonly found in groups or colonies, and frequently, throughout an extensive exposure, only one or two species can be met with. This is strikingly the case with the beds containing Perna, of which a fine example is presented in the Stratford cliffs, as formerly described. It is perhaps still more remarkable of certain strata of blue marl, found on the Potomac, at the point above named; upon the Rappahannock in several places, and at some localities in the interior. This marl presents a beautiful aggregation of very perfect small shells, (Mactra modicella,) bound together by a rather tenacious blue clay, and rarely exhibits a specimen of any other species. The abundance of this fossil in the blue marl in corresponding parts of the Meiocene tract towards the south, and especially on the south side of James river, has been particularly noticed in preceding reports.

The shells most usually presented in the marl beds of the neck are as follows:

Pecten Jeffersonius, scallop.
Pecten Madisonius.
Ostrea compressirostra, marl oyster.
Ostrea Virginica, marl oyster of small size and different shape.
Crassatella Marylandica, marl oyster.
Crassatella melina.
Mactra delumbis.
Mactra confraga.
Mactra modicella.
Chama corticosa.
Chama congregata.
Pectunculus subovatus.
Pectunculus pulvinatus.
Perna maxillata.
Isocardia fraterna.
Artemis acetabulum.
Arca idonea.
Arca stillicidium.
Arca centenaria.
Arca incile.
Venus mercenaria.
Venus deformis.
Venus cortinaria.
Astarte undulata.
Astarte vicina.

Venericardia granulata.
Fusus quadricostatus.
Fusus parilis.
Fulqur carica.
Turritella ter-striata.
Turritella alticosta.
Turritella plebeia.
Serpula granifera.
Crepidula costata.
Buccinum læqueatum.

SECTION VI.

ARRANGEMENT AND COMPOSITION OF THE EOCENE STRATA OF THE PENINSULA.

But little uniformity prevails in the arrangement of these beds, as observed at different localities. In general, the lowest stratum of the series is of a dark greenish blue colour, and those which lie above it have various shades of yellow, greenish, grey and brown. In many instances, the upper stratum is devoid of shells, but replete with their casts and impressions. Frequently, it is more or less impregnated with sulphates of lime, iron and alumina, which impart to it a styptic or astringent flavour, and with a small amount of sulphur, recognized by the odour it exhales when heated. All these ingredients, however, enter into the lower beds, though in less proportion, and are not excluded from strata containing shells. A thin band of ferruginous gravel, sometimes partially cemented, frequently overlies these beds, and forms the boundary between them and the Meiocene. We thus see a striking correspondence in the situation and condition of these and the upper Meiocene strata, and we infer that chemical agencies of a like nature have operated upon both.

SECTION VII.

LOCALITIES ON THE POTOMAC.

Extensive and valuable exposures of the Eocene are met with on this river. These strata first shew themselves a little above the mouth of Acquia creek, and continue, with but few considerable interruptions, as far as the eastern boundary of this deposit, at Mathias's Point.

Throughout much of this distance, a portion of the marl has the character of a hard rock, of a yellowish white or greenish gray appearance, abounding in shells and their impressions. The lighter coloured variety is always more or less specked with green sand, in rather large granules, and the darker contains this substance in larger quantity, uniformly diffused throughout the mass. The material enclosing the fossils, or their casts, consists largely of carbonate of lime, acting apparently as a cement. This rock may therefore be regarded as an EOCENE LIMESTONE.

At a point about a quarter of a mile below the mouth of Acquia creek, the cliff, having a height of forty feet, exposes the following strata:

1. From the water to the height of twelve feet, is a yellowish gray marl, specked with green sand, and abounding in shells, chiefly Cytherea ovata and Crassatella capricranium.

2. A ledge of rock, three feet in thickness, closely resembling the marl in colour and composition.

3. A layer of sandy clay, of a sulphur colour, containing shells, principally Turritella Mortoni. This is five feet thick.

4. A stratum of yellowish clay, enclosing impressions of Turritella, &c., and impregnated with the sulphates. This is twenty feet thick. About midway between the mouths of Acquia and Potomac creeks, the bank has an elevation of about fourteen feet, and consists of:

1. A layer of dark greenish blue marl, very remarkable for the multitude of shells, principally Crassatella, which it contains. This rises only one foot above the water.

2. A bed of shell rock, resembling the stratum beneath, but very hard, one and a quarter feet thick.

3. A layer of yellow sandy clay, containing Turritella Mortoni and other shells. This is at least seven feet in thickness, and is capped by a thin stratum of yellow clay.

In proceeding downwards, the shell rock, dipping gently to the east, becomes lower in the bank, and at length disappears near the mouth of Potomac creek. The bluish marl continuing beneath, first passes out of view.

The greenish blue marl again comes in view at the landing on the south side of Potomac creek, and still farther down, at about half a mile below the mouth of Paspitansy creek, the bank of the Potomac presents:

1. A stratum of this dark coloured marl, seven feet thick, containing some green sand and numerous shells, chiefly Turritella Mortoni, Crassatella capricranium and Ostrea sinuosa.

2. A bed of yellowish and reddish clay, thirteen feet thick.

A little below this point, a ledge of the shell rock makes it appearance in the bank, and continues, with but little interruption, down the river for several miles.

At some points two of the ledges are seen: one near the water level, and one at a considerable height on the face of the bank. This rock is replete with fossils and their casts, and consists, in large part, of carbonate of lime. In the same bank the marl is seen in the softer condition, and of both the yellowish and greenish blue varieties, overlaid by a stratum of the gypseous and acid clay. Among the interesting fossils here found, are two beautiful species of Cucullaeu.

At the Eagle's Nest and Mount Stuart, about three miles above Boyd's Hole, the Eocene strata are well exposed for some distance along the river bank.

At the former locality, the banks, which are from twenty to twenty-five feet in height, are composed of two strata: the lower, which is about twelve feet thick, consisting of dark bluish clay and sand, strongly imbued with copperas, and containing a little gypsum; and the upper, of coarse ferruginous sand and gravel. A few hundred yards below this point a thin layer, containing fossils, comes in view

about midway between the top and bottom of the bank; and as we proceed down the river, this shelly stratum expands in thickness, its upper boundary continuing horizontal, while its lower limit approaches the level of the beach. At a point about four hundred yards below the beginning of this layer, the strata are as follows:

1. Blue clay, one foot in thickness.

2. Shelly stratum, seven feet thick, indurated in some places so as to form a rock. This abounds in fossils, among which Carditas are most numerous.

3. Blue clay, containing copperas, and shewing ferruginous stains. Three feet thick.

4. Clay and sand, in part diluvial. Seventeen feet thick.

For upwards of half a mile below this, the bank presents the same series, the marl occasionally, at base a stratum from four to seven feet thick, consisting of blue clay, sometimes fossiliferous, and sometimes without shells, covered by a bed of ferruginous sand and clay of varying thickness.

At Boyd's Hole, the shelly stratum is not seen, but farther down, especially at Albion, and the other localities near Matthias's Point, before described, it again makes it appearance in the cliffs, and furnishes marls of a very useful quality.

On the Rappahannock, opposite *Port Royal*, at *H. St. L. Carter's*, and other localities on and near this river, the Eocene occurs, under circumstances very similar to those which have been described. In the interior of the peninsula, these strata are revealed in many places at the bottoms of the deep ravines, and in general consist of the dark greenish blue stratum, containing shells, overlaid by a bed of the gypseous and copperas clays. Frequently, however, only this latter bed is exposed in these situations, and some digging becomes necessary to reach the layer containing shells.

Towards the western limits of the Eocene, the shell rock very frequently presents itself, and together with the other strata of the formation, generally attains a greater height than in the localities farther to the east.

CHAPTER III.

THE NARROW BELT EXTENDING ALONG THE EASTERN MARGIN OF THE PRIMARY FROM PETERSBURG TO THE POTOMAC RIVER.

SECTION I.

OF THE FORMATION MET WITH IN THIS BELT.

The tract here referred to, though in general narrow, and often but vaguely defined, claims a separate consideration, as well on account of the interesting characters of the sandstone formation included within its limits, as by certain local peculiarities presented in

the Tertiary strata by which, at various points, this formation is overspread.

As mentioned in my report of last year, the primary rocks, in many places near their eastern boundary, are seen to be overlaid by a peculiar species of sandstone, in general characterized by containing a large proportion of white felspathic earth, whose imperfect cementing power imparts a soft texture and rather loose aggregation to the mass, and in some instances, leaves it in the condition of a bed of slightly adhering sand or pebbles. Though extensively exposed at various places on the Potomac, Rappahannock, North Anna, South Anna, James and Appomattox rivers, and on many of the minor streams, and in inland situations, these strata exhibit only at a few localities the peculiar vegetable impressions they contain in a sufficiently preserved condition to be of value in deciding upon the geological epoch of their formation. For the most part, these relics of a former vegetation are in the condition of charcoal, or of Lignite, sometimes approaching closely to a bituminous coal, and in these cases the markings are too vague to admit of identifying the vegetable forms to which they belong.

In some instances, however, very distinct impressions have been met with, unequivocal in character, and of such a nature as clearly to shew that the sandstones in question were deposited during a comparatively late period of the series of secondary formations, and are to be regarded as of more recent production than the various slates, shales, sandstones and conglomerates, described under the name of the middle secondary formation in my last year's report. They may, therefore, for the present, with great propriety, be designated as the upper secondary sandstones.

As indicated in the section included in the report of last year, and as mentioned particularly in the body of the report itself, we find in many localities resting immediately upon this upper secondary sandstone a succession of strata belonging to the Tertiary formation, consisting in some cases of the Eocene alone, and in others, including also superincumbent Meiocene.

As might be supposed, these overlying Tertiary beds are almost entirely confined to the eastern margin of the region occupied by the upper secondary strata, where, in virtue of the easterly dip of the sandstone, its surface is sufficiently depressed to admit of the Tertiary resting above. In the few instances, as in the locality at *Stafford* courthouse, referred to under a former head, where the Tertiary is met with at some distances within the general margin of the sandstone, it occupies but a small surface and appears to be in shallow cavities, and marginal indentations of subjacent formation.

The Tertiary beds thus met with adjoining the tract of sandstones, though often replete with the casts and impressions of shells, scarcely ever retain any of the original shelly material; which in most cases, has evidently been removed by the dissolving agency of the free sulphuric acid with which the surrounding sands and clays here, as in many other parts of the Tertiary region, are found even at the present time to be strongly imbued.

The peculiar feature of these Tertiary beds, in view of which I have proposed devoting to them a distinct consideration, consists in the occurrence of a very remarkable stratum varying from twelve to twenty-five feet in thickness, composed almost entirely of microscopic fossils between the beds containing the Eocene and those containing the Meiocene impressions.

This stratum which will be more particularly described under a subsequent head, giving no indications to the naked eye, or even under an ordinary microscope of its real composition, was until recently regarded by me as nothing more than a clay of unusually fine texture, such as is not unfrequently met with in the group of Tertiary strata. Nor was its true nature unfolded until struck by its remarkable lightness and its almost exclusively siliceous composition, and adverting to the recent discoveries of microscopic fossils in *Europe*, I was led to inspect it through a powerful microscope, when I found it to be made up almost entirely of exquisitely minute and delicate organic remains.

These curious relics, too minute to be described by the most penetrating eye, thus accumulated in a compact form into a stratum of great thickness, belong to a class of objects, which of late years have excited much attention in *Europe*, from having been found to constitute an important portion of the mass of extensive beds of earth and rock, and are in fact the shells and sheaths of various species of animalculæ, analogous to those which are met with in countless numbers in the waters of pools and marshes and in the sea, and which are denominated *Infusory Animals*.

Until the recent researches of the celebrated *Ehrenberg* disclosed the important agency of these minute beings in the production of some of the mineral masses belonging to former geological eras, as observed in *Europe*, no one had ever dreamed of finding whole strata of great thickness and extent, literally made up of these shells and other solid appendages; yet nothing is more certainly established than that these remains form not only the principal material of the light white earth which is known gradually to accumulate in peat-bogs and in other moist situations, of the Leaf Tripoli found in many parts of *Germany* in widely extended beds of many feet in thickness, of the Semi-Opal and other dense products met with in these beds, and of the common gun-flint found in layers of nodules running through strata of chalk, but that they compose in the shape of calcareous, as well as siliceous shells, and especially the former, nearly the whole substance of the vast strata of the chalk itself overspreading extensive districts of *Europe* to a depth in many places of several hundred feet!

In view of these interesting facts, the discovery of the Infusory stratum above referred to, as one of the members of our series of Tertiary deposits, cannot fail to be regarded as an important addition to our knowledge of the Tertiary of the country, and has the greater interest at present, from being the first example yet observed in the *United States*, of the occurrence of Infusorial remains in any but the *most recent* geological formations.

The most extensive developments of this stratum hitherto met with, are presented in the hills in the immediate vicinity of *Richmond*, and on the north bank of the Rappahannock river, in the neighbourhood and for some distance east of the eastern boundary of the Eocene on that river. The latter locality already alluded to, in connection with the geology of the Northern Neck, not lying within the tract of which I am now treating, does not properly claim to be described under the present head, and from having been visited long before the existence of infusorial remains in our Tertiary was even suspected, will merit further and more minute explorations.

Confining my remarks, therefore, chiefly to the former locality, and reserving a particular account of the latter, and such others as may yet be described for the final report, I proceed to treat, in order, first of the Upper Secondary sandstones and conglomerates, and secondly, of the Infusorial stratum and its associated Tertiary beds, found resting upon the Upper Secondary in the neighbourhood of *Richmond*.

SECTION II.

POSITION AND EXTENT OF THE AREAS OCCUPIED BY UPPER SECONDARY SANDSTONES AND CONGLOMERATES.

Sketch of the Boundaries of this Group of Rocks.

In attempting briefly to indicate the limits of the several areas occupied by these strata, I propose merely to give such an outline as by reference to the state map, will suffice to convey a correct impression of their general position and extent, without pretending to follow the boundary lines in all the various flexures through which they have been traced, and which are only capable of satisfactory exhibition by suitable delineations on the map itself.

The general direction of the tract in which these strata are developed, being marked by the eastern margin of the primary rocks, approaches closely to a meridian line passing through *Petersburg*, *Richmond* and *Fredericksburg*, bending a little eastward as it extends from the Rappahannock to the Potomac river. In this respect, it is strikingly distinguished from the belt occupied by the middle secondary rock, which as described in my last year's report pursues a general direction very nearly parallel to that of the Blue Ridge, and therefore nearly from northeast to southwest.

The narrow tract, extending from the Potomac to the Appomattox near *Petersburg*, in which the upper secondary sandstones are found, is not occupied by these strata throughout its whole extent. For much of the distance between the Rappahannock and North Anna rivers they cease to be disclosed within the artificial cuttings that have been made in this region or on the banks of the streams. But north and south of this deficient district they are met with, amply exposed, and have been traced continuously over areas of very considerable extent.

The more northern of these upper secondary tracts skirts the Potomac river from the upper extremity of the cliff at Mount Vernon, which marks the northern termination of the formation, to a point a little above the mouth of Meadow branch. At various points throughout this distance, the sandstones shew themselves in the river cliffs, extending in some cases to a considerable height above the beach. In the bank at Mount Vernon, that near White house, at Hight Point, Freestone Point, at the mouth of Quantico, as well as several intermediate places, they are well exposed, as shewn in the cliff at Freestone Point. Its thickness is between 60 and 70 feet.

Leaving the river bank at the point above indicated, the eastern margin of the tract crosses Meadow branch a little above the mouth of Still House branch, and bending around to a due south line, intersects Acquia creek, nearly half a mile below the mouth of Austin's run, and Accakeek creek at Brooke's mill. Bending its course towards the west and crossing Potomac creek a little above the church, it pursues an irregular line coinciding with the western margin of the Eocene, before described, passing near Gray's mill on Little Fall run, and extending in a southeasterly direction to a point on the Rappahannock, nearly opposite the mouth of Snow creek. On the southern side of the river it is resumed near the mouth of Massaponax, and thence continuing in a line a little east of the stream, crosses Long branch a short distance above its mouth, and then bending round towards the west, marks the southern termination of the exposures of the upper secondary strata, thus far met with in this portion of the belt.

Proceeding now to the western boundary of this northern area of the upper secondary, we find it extending from a point a little inland at Mount Vernon, in a direction nearly coinciding with that of the road marked on the map as passing through *Colchester* or *Occoquan*, in general, however, running somewhat nearer the river. Crossing Neabsco below the main road, it soon after bends westwardly across the road, and continues west of it and nearly parallel until it approaches the Valley of Quantico at *Dumfries*. Here the floor of Primary is laid bare over a considerable space, owing to the local denudation which has formed the valley of the creek; and the boundary line is made to sweep around in a course towards the east; but soon turning again westwards, on the south side of Quantico, it continues in that direction for about two miles, when suddenly turning to the south, it strikes across the Chopawamsic, and intersects Acquia creek near the mouth of Beaver dam; thence continuing a little west of south, it passes about a mile and a half west of Stafford courthouse, and then by a still more westwardly bend, strikes Potomac creek about a mile above Wallace's mill; from this point, it continues in a line east of south, crossing the Rappahannock about a mile west of *Falmouth*, thence curving westwards, so as to intersect the turnpike leading to Orange courthouse, at a point about three miles from *Fredericksburg*, crossing Hazel run still farther to the west, and then striking across to the Massaponax river, where it unites with the eastern boundary line previously traced.

The boundaries of the southern tract of the Upper Secondary strata are less distinctly marked than those of the area just described. For although extensive exposures of the rocks occur on the North Anna, Little, and South Anna rivers, and in numerous inland situations, the crumbling condition of the strata towards the margin, causes them so closely to resemble the loose sand and gravel which forms the usual covering of the Primary in this part of the state, as often to make it impossible to distinguish between them.

Instead, therefore, of attempting a detailed description of the outline of this tract, I shall content myself with indicating its form and dimensions by reference to a few well ascertained points. Its southern margin, passing nearly an eastward direction, lies about half a mile southward of the road leading from *Goodall's* across the heads of Stag and Falling creeks to Hanover courthouse. Where crossed by this road, the tract has a width embraced between a point a little west of Stag creek, and another point near *Mr. Winston's*, about four miles west of Hanover courthouse, comprising a distance of about eight miles. North of this, where intersected by the South Anna river, it extends from a little above the mouth of Buck creek to within a short distance of the South Anna bridge, as laid down on the map. Still farther north it expands eastwardly so as to occupy the bend of the North Anna, below the mouth of Little river; thence its eastern margin, prolonged in a due north direction, passes between the river and Concord meeting house. Its western margin crosses New Found river below the mouth of Beaver creek, strikes the road on which New Fork church is situated, half a mile east of the church, whence, intersecting Little river below New Market bridge and North Anna, near the mouth of Long creek, it is indistinctly traceable to the neighbourhood of Chesterfield depot on the rail-road, north of which position, no unequivocal exposures of the upper secondary strata have yet been met with, until we approach the southern extremity of the northern tract at the Massaponax river.

South of the tract above described, the upper secondary strata are not again met with until we reach the valley of Shockoe creek, near and within the city of *Richmond,* where they form thin and very variable beds of a coarse conglomerate and sandstone, in alternate layers, interposed between the primary rocks, occasionally exposed in the valley of the creek, and the Tertiary beds of which the adjacent hills are chiefly made up. Under the same characters, these strata shew themselves along the base of the river bank at Rocketts, and at various points below, to within a short distance of Deep Hole, at the eastern extremity of the island called Farra's island, where the Eocene strata are met with at the water level.

East of this, as was shewn in my last year's report, no deposits lower or of older date than the Tertiary are met with on the James river.

On the Appomattox, the upper secondary strata commencing at Bull Hill, a little below Broadway, where they are well exposed in the form of massive sandstones and conglomerates, and shewing themselves at Rocky Point, and for some distance along the river,

above the mouth of Cobb's creek, under the same characters, and in much greater thickness, are thence traceable, at intervals, up to *Petersburg*, presenting, however, less extensive exposures and a much looser aggregation.

Of the characters of these strata, as presented at some of the interesting localities on and near the James and Appomattox rivers, I purpose treating under the next succeeding head.

With the exception of the cliff at Rocky Point, the strata in question attain but little elevation above the water level, where observed either on the James or Appomattox rivers, and on this account, being deeply covered by diluvial matter, are rarely and very imperfectly exposed in situations remote from the river banks. Hence the extent to which they are spread out beneath the more superficial materials, must remain matter of conjecture.

In the two tracts referred to previously, they are generally met with at, or very near, the surface, and when exposed on the banks of rivers and streams, often exhibit an aggregate thickness exceeding fifty feet.

SECTION III.

CHARACTERS AND CONTENTS OF THE UPPER SECONDARY STRATA.

These strata consist of sandstones, slates, shales, and conglomerates, and, as might be anticipated, display much variety as to colour, texture and solidity. Within the northern area, previously described, they are very generally characterised by containing a large proportion of felspathic earth, which, interposed between the siliceous grains forming nearly all the remaining material of the rock, imparts to it the open texture of a freestone, and renders it capable of being easily wrought for architectural purposes. Indeed in many cases, this material, by its great predominance in the mass, interfering with the partial adhesion of the siliceous matter, so impairs the aggregation of the stratum, as to cause it quickly to crumble into a loose sand.

In the composition of the variety here in view, the siliceous grains thus enclosed in the soft felspathic material, are of well rounded forms, and in the beds usually resorted to for building, of small and rather uniform size. But along with strata thus constituted, layers and heavy beds of coarse conglomerate are not unfrequently met with at the quarries and other exposures in the northern tract, and have been observed at some points in the neighbourhood of the North and South Anna rivers. In neither tract, however, do they constitute a large part of the mass of the formation.

The presence of these coarse materials in predominant proportion, appears to be confined to the neighbourhood of the James and Appomattox rivers, where it is conspicuously displayed at nearly every exposure.

The finer variety of the felspathic sandstone, where of uniform texture, free from specks of ferruginous matter, and exempt from an excess of the felspathic earth, possesses many valuable qualities

as a building material, combining sufficient strength for most architectural purposes, a fair degree of durability under exposure to the weather, a pleasing light brownish grey colour, and a texture well adapted for the ordinary operations of the mason's chisel, or even for ornamental sculpture. While in the capacity of sustaining great weights without being crushed, it is no doubt inferior to some other varieties of building rock employed in this country, it is well adapted by its other qualities for numerous applications, in which the incumbent load is not excessive, and where a wrought or ornamental surface is required. These important advantages have been so well appreciated, as to have brought it into extensive use in the construction of the public edifices in *Washington*, and have in this way for a series of years given active employment to numerous quarries in the neighbourhood of Acquia creek, and on the Rappahannock river. Of these, the most extensive are the quarries of *Messrs. Stone*, *Gallahorn*, *Towson*, *Beard*, and *Adie*, situated near the head of Austin's run—those of *Messrs. Wallace*, *Brooke*, and *Edwinton*, adjoining Acquia creek, and those of *Messrs. Fitzhugh* and *Taliaferro*, on the Rappahannock river.

At all these localities, the thickness of the strata exposed is very considerable, varying from 20 to 50, or more feet, and, as might be expected, presenting among the different beds of rocks marked varieties in texture and composition.

At the extensive quarry of *Mr. Gallahorn*, the rock is for the most part a nearly white sandstone, devoid of ferruginous stains, presenting the appearance of a bed of agglutinated sand, without distinct layers, and lying nearly in a horizontal position, and possessing a remarkably uniform texture, and being free from joints, it is readily loosened from the quarry by wedges in blocks of any required size. A few layers of coarse conglomerate are seen extending through the mass. At the quarry of *Messrs. Beard* and *Adie*, the rock is a light coloured sandstone, but appears in distinct layers from 2 to 4 or more feet in thickness. Similar characters prevail at the other quarries on Austin's run and Acquia creek.

The quarries opened for the construction of the rail-road bridge over Potomac creek, about half a mile above the church, present very extensive exposures of the sandstone. It is here seen on both sides of the creek, forming cliffs of from 60 to 70 feet in height, and has been applied both in forming the piers and the abutments of the bridge, that used for the latter purpose being quite coarse, and derived from the upper layers.

At the quarries of *Mr. Francis Taliaferro*, situated on the Rappahannock river, about half a mile above the mouth of Massaponax, the sandstone extends from 20 to 25 feet above the water. It is in general a compact, well cemented rock, varying from a nearly white to a light brownish grey colour. The latter tint is generally developed after exposure to the air, and is obviously due to the decomposition of the embedded particles of iron pyrites present in the strata of this as well as other localities.

It may be well to remark, that the ferruginous stains, so commonly presenting themselves upon the weathered surfaces of the rocks of which I am treating, though injurious to the beauty of the stone, are not likely to impair its durability, unless the decomposing pyrites be present in very large amount, and in ordinary cases, the blemish may be readily corrected by the application of a coat of paint.

Associated with the sandstones above described, there occur in the northern tract various strata of shale and slate and sandstone, presenting at certain localities a number of interesting vegetable impressions and other remains. Of these it is not my purpose to speak in detail at the present time. It will be sufficient to remark, that the characters of these remains are such as to throw important light upon the geological history of the strata with which they are associated, and will therefore entitle them to a detailed consideration, when I shall be called upon to illustrate the interesting scientific relations of the upper secondary rocks. I may also add that the lignite and charcoal derived from the decomposition of these vegetable substances, and so abundantly displayed in many localities, though seemingly in favour of the existence of beds of coal in this formation, have no essential connection with extensive deposits of this material, and that in view of the age and general character of these upper secondary rocks, as well as the extent to which they have been explored, there is no reason for believing that they contain any seam or bed of coal worthy of economical notice.

Adverting now to the strata as presented in the southern tract, I would remark that while in many respects analogous to those above described, they display modifications of colour, texture and composition entitling them to a separate notice. Instead of the whitish, open-grained freestone, so predominant in the northern tract, we here meet with bluish grey sandstones, composed of fine particles of sand blended with impure felspathic clay and some scales of Mica, others of a similar texture but of a brownish tinge; coarser sandstones in which white felspathic earth and coarse siliceous grains are interspersed in these finer materials; brown and olive coloured slaty sandstones and argillaceous slates, together with other varieties bearing the same general character, and along with these at some localities beds of felspathic freestone similar to those of the northern tract. As a general rule, the rocks in question compared with those of the district to the north, are of a darker hue, contain more Mica, and are of a finer grain and softer texture. In most exposures they are seen in a crumbling state when acted on by the weather, and are in general possessed of little strength or durability. Localities, however, are not wanting capable of affording rock of a better quality; and to these resort has been had in the vicinity of *Taylorsville* and elsewhere, for the uses of the rail-road.

Lignite and thin seams of impure bituminous coal are of frequent occurrence in these rocks, especially towards the southern extremity of the tract. In the bluish and brownish grey soft sandstones met with so generally in the neighbourhood of *Taylorsville*, on the North Anna and Little rivers, stems and other vegetable fragments are often

found, presenting the condition either of bituminous coal or charcoal; thin layers of slaty lignite are not unfrequently exposed in the same rocks, and have led to the fallacious idea of the presence of important beds of coal in their vicinity. Towards the southern margin, the sandstones in many places are largely intermingled with dark coloured micaceous slates and bituminous shales, among which are found thin seams of an impure bituminous coal. Exposures of this kind occur at several places towards the western side of the tract, on Beach and Stag creeks, presenting the following appearances.

On Beach creek, at *Mr. Lowerre's*, a grey siliceous sandstone occurs, associated with much dark micaceous slate and black glazed bituminous shale, a coarse conglomeritic sandstone, and brownish soft shales, enclosing a very thin seam of bituminous coal.

On the Poor house tract, situated on Stag creek, we find grey felspathic sandstone of fine grain and rather compact texture, associated with brownish and black bituminous shales. The latter, at the spot which has been explored for coal, contains two small layers of that substance, rather irregularly disposed in the shale, the entire bed, shale and coal included, being about five feet in thickness.

Farther to the east the bituminous shales are rarely met with, the rocks consisting of coarse conglomeritic sandstone, reddish brown micaceous shales, and loose grained felspathic sandstone, generally stained with oxide of iron. At one or two points in this vicinity small patches of the Tertiary strata are met with in the form of a light greenish grey micaceous clay or loam, impregnated with sulphur and sulphates, and containing casts of univalve and bivalve shells, but without any remains of shelly matter. The dips of the strata above described as disclosed in the southwestern corner of the tract vary from northeast to southeast, and even to northwest, and are often as high as forty-five degrees, in this respect differing from the upper secondary strata in the more northern and eastern portions of the belt. It may, indeed, be observed as a general fact that the deviation from a horizontal position is greater in the southern than the northern tract, and that it is seen to increase as we proceed southwestwardly in the latter.

The proximity of the district on Beach and Stag creeks, to the coal basin of the Deep Run and Springfield pits, south of Chickahominy river, and the general resemblance of its rocks to those of the coal measures, added to the fact of the actual discovery of coal in the localities just described, have led to the supposition that the true coal rocks are extended northwards of the Chickahominy, and will there also be found to include a valuable seam or seams of coal. Careful observations, however, have clearly shewn that the measures of the basin south of the river, nowhere extend over to its northern bank, but are walled in by a barrier of primary rocks, which have been traced entirely around their northern termination, and that the tract between this and the southern margin of the upper secondary, traversed by the road leading to Ground Squirrel bridge on the South Anna, is entirely primary.

There is, however, reason to believe that the rocks in the south-west corner of this upper secondary tract are more nearly allied in age to those of the true coal basins lying to the south, than the strata generally to which I have provisionally given the name of upper secondary, and that occupying somewhat an intermediate place in the series, they might be expected to present a more close resemblance to the coal measures both in character and contents than the other strata of either the north or south upper secondary tracts.

As essentially connected with this subject, it is important to remark, that after much investigation as regards the true geological character of the coal basins of *Henrico*, *Chesterfield*, &c., I have become satisfied that instead of being older, they are of more recent production than the carboniferous strata of our great western coal region and most of the European coal measures, and that the era of their formation is not widely removed from that of our upper secondary strata. Of the various data which have served to illustrate this very perplexing enquiry, it would be inappropriate to enter into an account in this place; suffice it to say, that notwithstanding the rareness of well preserved fossils in these coal fields, I have at length been enabled to procure such as are adapted to shed important light upon the interesting question above alluded to, and connected with other considerations, to lead to conclusions at once curious and satisfactory.

Of the upper secondary strata, as exposed on the James and Appomattox rivers:

As formerly remarked, the exposures of these beds in the district here referred to, are almost exclusively confined to the abrupt river banks, and to certain points adjoining the primary in the deep ravines below *Richmond.* Some observations upon the general composition and character of these strata, along with a description of one or two interesting localities, will suffice to convey a just conception of their peculiarities, and will render farther details unnecessary.

The loose aggregation and coarse materials of these beds, give them so great a resemblance to the common diluvium of sand and gravel, generally forming the surface strata in this part of the state, as to render careful observation necessary in order to distinguish between them, and even the closest inspection, in some cases, will scarcely suffice for this purpose. This obscurity, however, does not apply to localities in which the Tertiary beds are seen resting upon them, as in such cases the subjacent position of the sandstone or conglomerate determines its true geological character, the diluvial sand or gravel having its place above the Tertiary.

The difficulty of making this distinction is chiefly felt in relation to some of the exposures on the rivers, where the Tertiary having been removed by denudation from above the upper secondary beds, has been replaced by the mass of diluvial sand and gravel, deposited upon the broken surface of the secondary, often no doubt with much intermixture of the materials of the two; but even in these cases a marked difference may be noticed in their composition, especially in the fact of the comparatively large amount of white felspathic earth

blended with the coarser matter of the upper secondary. Indeed, at most localities, however large may be the pebbles imbedded in some of the layers, the intervening matter will be found to possess the character of a soft felspathic sandstone, and some portions of the mass will display this character throughout.

The pebbles thus imbedded in the finer material of these beds, sometimes in layers of many feet in thickness, but oftener in narrow courses, are frequently of great size, measuring even as much as eight or ten inches in diameter. They are of very various origin; some being from the primary region, and consisting of Quartz, Gneiss and primary slates, while others are from the formations farther west, and especially that lying on the valley side of the Blue Ridge, and which I have designated as the first of the series of rocks of our great Appalachian system. These fragments of formation I., remarkable for their bright white colour and their great magnitude, serve to distinguish the mass in which they occur from the overlying diluvium, in which nothing analogous has as yet been discovered. Forming, thus, part of what may be considered as ancient diluvium, belonging to the secondary era, they point to the extensive agency of the currents by which the heterogenous materials of these upper secondary strata were swept together.

At Rockets, immediately below *Richmond*, may be seen beds of the soft felspathic sandstone, with layers of coarse gravel and pebbles lying near the base of the bank, and above these, beds of clay, sand and gravel, referrable to the common diluvium. Similar appearances present themselves at various points lower down the river, and are well observed on the land opposite Farrar's island. Here, adjoining the wood wharf near Osborne's ferry, the river bank rising abruptly, presents a good exposure of the soft felspathic sandstone and gravel for a height of about 24 feet. For some feet below the floor of the wharf, and as low down as the water level at medium height, the bank consists of brownish soft sandstone, enclosing a few pebbles. Above this is a nearly white felspathic sand, partially cemented, with a few layers of white pebbles; and still higher, a heavy bed of similar pebbles, packed in layers of the felspathic sand. Strata of a similar character, enclosing pebbles of huge dimensions, together with rounded masses of clay, occur at the ferry.

In the vicinity of *Petersburg*, similar materials are exposed along the base, and for some height in the hill forming the northern boundary of the river bottom, and may be seen at the cuttings for the railroad and other roads in that direction; a thin layer of Tertiary clay here separates them from the upper diluvium. Southeast of the Appomattox, the surface is a table land raised between 30 and 40 feet above the water. This extends down the Appomattox to Bull Hill, which, commencing a little below Broadway, forms the river bank, thence for some distance towards City Point. The strata lying beneath this plain are of the same character as those just described, and are doubtless the upper secondary sandstone overlaid to some extent by modern diluvium. East of this an upper level rises rather abruptly, marking the western margin of the great Tertiary plane, which thence extends eastwards towards the sea.

The steep bank exposed along Bull Hill, discloses the felspathic sand and pebbles for some height, capped by ferruginous clay and sand, while on Bull Hill creek, which enters the river at the eastern extremity of the hill, we find sandstone and conglomerate of very firm texture in heavy beds, rising above the water from 12 to 15 feet. Rock of a like description is also exposed in the bank a little above Broadway.

But by far the most interesting exposure of these strata to be met with on the Appomattox, are those of Rock Point and its vicinity, on the west side of the river and below Cobb's. An abrupt bank here shews itself about thirty feet in height, of which nearly the whole is well exposed, consisting of the felspathic sandstone and conglomerate in huge beds, lying nearly horizontally, and divided to a great depth by vertical joints. Most of this rock is thickly interspersed with pebbles from one to two inches in diameter, the intervening material consisting of felspathic sand, and the whole being quite compact and hard. Numerous large masses that have tumbled from the cliff, and now lie at the water's edge or in the water, strikingly attest the durability of this variety of rock.

Other layers are crumbly and fall into sand. Huge pebbles lie imbedded in the finer material, some of them not less than 12 inches in diameter, beautifully white and fine grained, and evidently derived from formation I, of the Appalachian rocks.

The lower extremity of this cliff, and the banks of Bull Hill creek, terminate the exposures of the upper secondary on the Appomattox. The plain between the Appomattox and the James river, towards the junction of the two, presents occasional exposures of the Tertiary, and beds of this formation begin to shew themselves as we trace the Appomattox shore towards *City Point*. We may therefore approximate to the common boundary of this and the secondary sandstones, by a line drawn from the mouth of Bull Hill creek to the neighbourhood of Deep Bottom on the James river.

SECTION IV.

INFUSORIAL STRATUM AND ASSOCIATED TERTIARY BEDS IN THE VICINITY OF RICHMOND.

Having adverted to the general character of what are called Infusorial remains under a former head, I shall confine myself in what follows to a brief description of the more striking peculiarities of our Infusorial stratum, and thence proceed to a sketch of the geology of the district in and adjoining *Richmond*, in which it has been my good fortune to find it developed.

The material in question, composing a thick stratum lying between beds of sand and clay, is more or less mingled with them, particularly in the vicinity of its bounding surfaces. But throughout most of its thickness, it presents a very fine texture, admitting of being bruised by the fingers into an almost impalpable powder, and singularly free from gritty particles. Its colour in the present specimens,

is a very light grey or white, but the fragments into which it spontaneously divides at the exposed surface of the stratum, often present externally a slightly ochreous tinge. It is decidedly, though sometimes indistinctly laminated, the planes of the thin flakes or sheets being horizontal. When moistened, it displays considerable tenacity, and hence has hitherto been regarded as a fine clay or fullers earth.

Of all its peculiarities, however, capable of being readily discovered, its great lightness is the most extraordinary and characteristic. When quite free from moisture, a pure specimen has a specific gravity of only 0.334, that is to say, only one third the weight of water, bulk for bulk.

In adverting to the curious and astonishing fact of its being composed almost entirely of the shells and other appendages of former races of animalculæ, it was also mentioned that unlike the microscopic remains composing the chief mass of chalk or the larger fossils of our marl beds, these minute relics consist entirely of *siliceous* instead of calcareous matter. For this reason it is, that the Leaf Tripoli, or Polir Scheifer of *Bohemia*, as well as other analogous Infusorial products, have so long been found valuable in giving a polish to metallic surfaces. Our Infusorial matter, when properly selected, is capable of being employed for this purpose with no less advantage, and from the trials I have made, I feel assured that when exempt from grit, it may be very usefully substituted for the finer varieties of the Tripoli or rotten stone of the shops.

Of the forms of these microscopic remains, no just conception can be conveyed to the general reader without the aid of drawings representing them on a greatly enlarged scale. I may however remark, that while these forms are very numerous, and refer themselves to many distinct species of minerals, they may in a popular way be described as for the most part referrable to two classes.

One of these is an oblong cylinder, rounded or knobbed at the extremities, and containing within a multitude of rings arranged parallel to each other, from end to end, and forming, as it were, the internal skeleton of the animal. The other is a round disc, more or less convex, and sometimes nearly spherical, often perforated through the centre, and presenting over its surface an exquisite net work of inconceivably minute belts.

Of the minuteness of these objects, some idea may be formed from the following statements:

The cylindrical bodies of the medium size are from $\frac{1}{300}$th to $\frac{1}{400}$th of an inch in length, and from $\frac{1}{1200}$th to $\frac{1}{1600}$th in width, but many fall greatly short of these dimensions.

The rings, which are found separate in great numbers, are usually from the $\frac{1}{1500}$th to the $\frac{1}{2000}$ of an inch in diameter.

The circular discs and convex bodies, reticulated with cells, vary from $\frac{1}{100}$th to $\frac{1}{600}$ in diameter. In each of these are hundreds, and even thousands of beautifully wrought cells. The predominance of these flattened forms appears to be the cause of the laminated texture already mentioned as exhibited by the Infusorial earth. It is obvious from these facts, that the number of such fossils comprised in

each cubic inch of the material, can only be reckoned in millions or hundreds of millions, and that a bushel measure would contain a number of these skeletons and shells of former races of animalcula, far exceeding the entire population of the globe. Of the important geological agencies of the living races to which these remains belonged, we need no more striking illustration than will be furnished in the following sketch of the extent and relations of the Infusorial stratum. And I may add that while, as formerly remarked, this stratum at *Richmond* and on the Rappahannock, furnishes the only instance in which these remains have been found in the *United States*, forming portions of any formations but those of the present epoch, its thickness and the extent over which it is spread out, entitle it to rank with the most interesting beds of siliceous Infusorial remains yet discovered in *Europe*.

The valley of Shockœ creek, lying between Shockœ hill and Church hill, affords numerous favourable opportunities of observing the position of the Infusorial bed, and the strata with which it is associated, by explorations along the sides of the bounding hills and the deep ravines by which, in many places, they are abruptly trenched.

The middle of this valley is occupied by coarse gravel, rarely discovering any materials *in situ*. Beside the stream, a little to the left of the crossing of Shockœ hill main street, as continued over towards Church hill, a patch of primary is displayed, consisting of Gneiss containing some Hornblende, and intersected by several veins of Felspar.

At the base of Shockœ hill, a short distance up the principal ravines, the felspathic sandstones and conglomerate may be seen, forming the channels of the little rivulets flowing in these hollows, and rising, when best exposed, to a height of about five feet above the bottom of the ravine. Of course, near the outlet of the hollow, the heavy diluvium from the upper part of the hill conceals or replaces every thing else, and neither the felspathic sandstone or overlying beds, can be seen, until we enter some depth into the ravine. We may thence trace it upwards, until, in consequence of the slope of the surface, we reach a higher level than the upper limit of this rock, when it disappears from view. This stratum consists of the felspathic sand in irregular layers, loosely cementing pebbles of various dimensions from 1 to 4 or 5 inches, some of which belong to formation I. An analogous material is still more extensively exposed in the mill race at the mill, higher up the creek, and composes the low knoll on which the mill is placed. Here we find the felspathic sandstone in general much stained with ferruginous matter, overlaid by a bed of very coarse conglomerate of an ochreous stain and unusual hardness. Similar sandstones and conglomerates are displayed at various points along the margin of the stream, for a thickness of several feet above its surface.

Resting upon this sandstone and conglomerate, we meet with beds of sand and sandy clay of a dark greenish and lead colour, and of a light grey, mottled with yellow, containing Sharks' teeth and Eocene carditas, Turritellas, Crassatellas, &c., in the form of casts, together

with vague vegetable remains in a carbonized condition. The contact of these Eocene strata with the underlying sandstone, is well displayed at the following points:

1st. The ravine adjoining Shockœ hill Main street, where the culvert opens.

2d. That heading immediately in the rear of the Monumental church.

3d. That between Col. Ambler's hill and French Garden, by far the most prolonged of the ravines on this side of the valley.

4th. That next above French Garden and between it and the Poor house. Above the point last named, the sandstone is buried out of view, and the lowest stratum seen belongs to the Eocene.

Above these Eocene beds occurs the enormous deposit of Microscopic remains, which I have called the *Infusorial stratum,* having the bright grey or nearly white tint, and the astonishing lightness before described.

This stratum shews itself at nearly the same level on the hill sides, and in the ravines on both sides of the valley of Shockœ creek, and may be traced on the Shockœ hill side of the valley, without interruption, as far as the crossing of the Hanover road towards the head of the valley and near Turner's mill. From a point on the slope of Church hill, a little beyond Butchertown, commanding a view of the hills and ravines from the Poor house down, it is easy to trace the broad belt of this deposite by its surface being comparatively derived of herbage, and presenting a white and barren aspect.

The thickness of the stratum varies at different points from 12 to 25 feet, the most striking exposures being those met with in the ravine behind the Monumental church, and that between Col. Ambler's and French Garden.

The same, or a very similar order is observed, in the exposures visible on the opposite side of the valley along the slope of Church hill. At the bottom of the ravines, which are here comparatively shallow, we see the upper portions of the Eocene, and over this the Infusory stratum, shewing itself plainly and of great thickness, at the following points:

1st. Just back of Butchertown, on the two roads that extend up the hill.

2d. At the foot of the abrupt bare bank which has been cut into north of the Main street, on Church hill, and thence south nearly to the next street.

Indeed, along the slope of Church hill, as on the other side of the valley, this stratum may be found in all the ravines and cuttings at the proper level.

Above the Infusorial stratum, are lead-coloured and ochreous sands and clays, sometimes nearly resembling it in colour, but readily distinguished by their greater heaviness. These, which belong to the Meiocene division of the Tertiary, are remarkable for containing, near and for some distance above the Infusorial stratum, numerous vegetable markings of a vague description, as well as many well defined impressions of leaves and stems; and towards the top, impressions of Scallop shells (Pecten) and other Meiocene fossils. Among

the numerous points at which these strata are exposed, the following may be mentioned as interesting and easy of access:

1st. On Governor street, as you descend Main street, where the impressions of shells are very numerous.

2d. The steep bank opposite the Synagogue. Here the clays near the base, abound in vegetable impressions, among which are admirably defined leaves. Towards the top, the more sandy material contains impressions of Pectens.

3d. On Church hill, back of *Mr. Van-Lew's* garden, and the bare bank exposed along the valley side of the hill behind *Mr. Greaner's* dwelling. The base of this bank is on a level with the top of the Infusorial bed.

The minute details which have now been presented in relation to the Infusorial bed and its associates, though unimportant to the general reader, are here given, that those residing near may be enabled to gratify their curiosity by observing for themselves the extent and relations of this curious deposit. I will now conclude the subject with the following:

Section of the Stratra disclosed in the principal Ravine on the west side of the valley of Shockœ Creek.

1st. Felspathic sandstone, upper secondary, - -	4 feet.
2d. Dark olive and bluish stratum, tenaceous while moist, but becoming mealy and of a greyish tint when dry, and in that condition shewing an efflorescence of gypsum upon the surface. Impressions of Cardita, &c.—EOCENE,	4 "
3d. Lighter coloured bed, with yellowish blotches, and streaks very friable even when moist, being more sandy than the preceding. A few impressions.—EOCENE, -	8 "
4th. Brownish black, containing a few prints of fossils and a large amount of carbonized vegetable matter, to which the colour of the stratum is owing, - -	5 "
5th. Lead coloured heavy clay, with a greenish tinge,	3 "
6th. INFUSORIAL STRATUM, - - - - -	20 "
7th. Greenish brown and lead coloured clays, with vegetable impressions.—MEIOCENE, - - -	6 "
8th. More sandy stratum of mottled grey and yellowish brown, vegetable impressions and prints of Pectens.—MEIOCENE, - - - - - - -	14 "

Above the last named bed are others belonging also to the Meiocene, but they are too imperfectly exposed for accurate observation. On top of these, and forming the highest of the deposits in this vicinity, are the beds of diluvium, composed of sand and gravel.

CHAPTER IV.

NORTHERN DISTRICT BETWEEN THE BLUE RIDGE AND HEAD OF TIDE.

SECTION I.

PLAN OF EXPLORATION—GENERAL GEOLOGY.

A general examination having been made of a large portion of this region in former seasons, as indicated in my last and some of the preceding reports, our operations were directed almost exclusively to the investigation of detailed sections, and to the minute tracing of the several formations and more important bands of rock met with in the district, with a view to their delineation on the map, associating with these labours the careful exploration of all localities where materials of economical or of curious interest might be found, as well as the collection of ample suites of specimens for geological illustration and chemical analysis. In the execution of these objects, our progress, though in some degree arrested by the lamented event referred to in the beginning of this report, has been sufficiently great to enable me in conformity with the plan adopted last year, to present a systematic, though brief account of the more interesting features of the district. In doing this, however, I wish it to be borne in mind, that in many parts of the district our researches are far from having been completed; and that consequently, in the descriptive sketch now about to be presented, important areas as well as interesting individual localities, will require to be omitted, while at the same time the illustrations, so far as attempted, will aim at as much accuracy as can be attained in the compendious form to which they are limited, and without the accompaniments of a map and sections.

Entering upon our researches with a view to minute detail, the following principal sections were proposed for examination at the opening of the season, being designed as the frame work for intervening observations:

1st. Along James river from *Columbia* to *Richmond*, connecting at the former point with a section constructed the preceding year, thence to the *Blue Ridge*.

2d. From *Swift Run Gap* by *Stanardsville, Barboursville* and *Louisa courthouse* to *Hanover courthouse*.

3d. From *Thornton's Gap* by *Fairfax*, (Culpeper courthouse,) *Stevensburg*, *Germanna Ford* to *Fredericksburg*.

4th. From *Ashby's Gap* by *Paris, Aldie, Fairfax courthouse* to *Alexandria*.

5th. From *Chester Gap* through *Warrenton* to *Dumfries*.

6th. Along or near the Potomac river from *Harper's Ferry* to *Georgetown*.

Of these principal sections, two have been entirely, and one nearly completed, and each of the others more or less advanced, at the same

time that numerous shorter intervening sections have been explored either partially or to completion, and a satisfactory progress made in the longitudinal tracing of the more important belts of rock.

In these investigations, as usual, particular attention has been directed to such deposites as are or promise to be of economical value, and in this view, the various patches or interrupted ranges of limestone, as well as the iron ores, slates and building rocks generally met with in the tracts observed, have been carefully examined.

After what has already been stated, it is scarcely necessary to repeat, that although in portions of the district under consideration our enquiries have been quite as extensive and minute as could be desired, much additional observation is demanded for the completion of the sections yet in an unfinished state, as well as for bringing to a close the various local researches thus far omitted, or but in part accomplished. These will, it is hoped, form a portion of the duties of the coming season, when, as I have previously stated, it may be confidently expected that our field labours in this as in other parts of the state, will be brought to a satisfactory conclusion.

The general geological features of the region now in view are closely correspondent to those of the district south of the James river, of part of which a somewhat detailed account was presented in the report of last year, and I may, therefore, refer to the descriptions then given in connection with the glossary to be appended to the present report, for a full explanation of the composition and more striking characters of the rocks and minerals of which I am about to present a few brief details.

Throughout the greater part of this region, the rocks are of PRIMARY and METAMORPHIC characters, consisting chiefly of Gneiss, Mica slate, Talcose slate, Epidotic rock, Hornblende slate, Argillaceous slate, Quartz rock, Quartz slate or Quartzite, and Pseudo Gneiss or Gneissoid sandstone, with occasional beds of Granite and Sienite. With these are associated numerous beds and dykes of Trap, and over a large space towards the centre of the district, are spread out the nearly horizontal strata of sandstones, shales and conglomerates, corresponding to the belt referred to in my last year's report under the name of the MIDDLE SECONDARY FORMATION. Towards the eastern margin of the region occur the felspathic sandstones and associated beds of the upper secondary strata, and the interesting formations of the Deep Run and Tuckahoe coal basins, of the former of which some account has already been given in the present report.

In the following brief illustrations of the geology of this region, I shall treat,

First, of the primary and metamorphic rocks, including the beds of limestone associated with them at various points; and, *secondly*, of the middle secondary tract.

SECTION II.

OF THE PRIMARY AND METAMORPHIC ROCKS, INCLUDING THE BEDS OF LIMESTONE ASSOCIATED WITH THEM AT VARIOUS POINTS.

Referring, as already mentioned, to my last year's report, and the glossary appended to the present, for an account of the composition of the several classes of rocks of which I am about to speak, I propose treating of them in the order of their relative extent, and will therefore begin with

GNEISS.—Rocks of this description occupy a large portion of the district. Besides being met with in intermediate lines, they are largely developed in two extensive tracts, one of which stretches in the form of a belt from the eastern flank of the Blue Ridge to the neighbourhood of the Southwest mountain in Albemarle county, gradually contracting in width in its prolongation towards the northeast, and finally near the Potomac, compressed between the eastern flank of Short hill and a line some distance west of the Kittoctin mountain, the other forming an irregular triangular area, having its apex a little west of *Fredericksburg*, its eastern side in a nearly meridianal direction, coinciding with the eastern limit of the primary rocks along the head of tide, and its western side parallel to the general course of the Southwest mountain, and terminating a few miles west of *Columbia.*

The Gneiss of the westernmost of these tracts is in general of a darker colour and coarser texture than that of the other, especially towards the eastern margin of the latter. It also presents much greater variety in its composition. In most localities, with comparatively little Mica, it contains more or less Talc, occasionally Chlorite, and in a great number of cases, Hornblende and iron Pyrites, the latter aiding its disintegration, and along with the Hornblende, imparting more or less of a reddish tint to the soil into which it is resolved. Near the eastern base of the Blue Ridge, as for example in approaching Swift run, Thornton's or Ashby's gaps, a variety is met with, sometimes extensively exposed, containing a bluish somewhat milky Quartz, and in the same tract, belts or ranges of Granite or Granitic Gneiss occur, into which the adjoining rocks seem insensibly to graduate. In this belt also occur bands of Micaceous and Talcose slates, sometimes of such breadth as greatly to encroach upon the area of the Gneiss, but in general occupying only a small part of its entire width.

These, as might be expected, are not very distinctly defined, but pass into the Gneiss by imperceptible degrees. With a very few local exceptions, the Gneiss and associated slates of the belt in question have a strike nearly to NE. and a steep dip towards SE.

The Gneiss rocks of the eastern tract likewise display several varieties. Along the eastern margin, and for some miles westward, the variety chiefly met with is a grey rock, consisting of Quartz, Felspar, and black Mica, with occasional spangles of white Mica, and scattered grains of Hornblende. It is of an even texture, readily separating

in large slabs and blocks, suited for columns and other purposes. Being easily wrought to a smooth surface, and to any required shape, and possessing, when properly selected, as great durability and strength as is necessary, it is deservedly looked upon as a material of great value in architecture. Of this variety, innumerable exposures are presented on both sides of the James river in and above *Richmond*, and on the Appomattox in and above *Petersburg*, and a similar rock, though in much less extent, is seen on the Rappahannock above *Fredericksburg*.

Along the James river canal above *Richmond*, it is displayed almost without interruption for a distance of many miles, presenting various modifications of texture and composition, but in the main preserving the general characters above described. Though subdivided by joints cleaving the strata to great depths in planes of great steepness, and of which the principal one dips towards the southeast, the bedding or stratification of the rock is not in general steeply inclined, but undulating and with a prevailing dip towards the same point. A similar remark is applicable to the Gneiss on and near the Appomattox in the vicinity of *Petersburg*, as may readily be verified by reference to the exposures near the mills within the town, and on the opposite side of the river, as well as the quarries near and above *Battersea*.

An intimate blending of the Quartz and Felspar, and a large predominance of the former, are important characteristics of the most valuable beds of this rock, and should be borne in mind where a selection is to be made for architectural purposes. In some of the layers, the Felspar is met with in great excess, imparting to the stone a tendency to crumble by exposure, in consequence of the conversion of this ingredient into a white powder, (Porcelain earth,) and the loosening of the grains of Quartz. To distinguish between the Felspar and Quartz, it will be recollected that while the former is of a dull white or pinkish hue, and opaque, the latter is transparent; and that while the former, after some exposure, presents more or less of a mealy surface, the latter retains its clearness and lustre unchanged.

At various localities both on the James and Appomattox rivers, extensive beds of this Gneiss occur, of so fine and even a grain, as to admit of delicate sculpture, and of being wrought down to a smooth and almost polished surface. The pleasing light grey tint, and the undoubted strength and durability of this variety, give it a very high value as applied to the construction of steps, sills, monuments, and ornamental as well as substantial masonry in general. I need scarcely add, that the exposures above referred to, present numerous very favourable positions for quarrying and for transporting the stone to the neighbouring cities, or to the seaboard, and that considering its beauty, durability, facility of being wrought, and convenience of position, it cannot fail to become an important item in the resources of the particular neighbourhoods in which it is found thus favourably situated.

Besides the occasional beds of coarser Gneiss, containing much pinkish Felspar in large crystals, and presenting, though stratified, the composition of a Syenite or Syenitic Gneiss, we find at nearly every

quarry veins of Felspar traversing the beds in various directions, and not unfrequently subdividing and mutually intersecting. These are usually of small dimensions, rarely exceeding two or three inches across. But besides these, we observe at many exposures, veins and dykes of Granite and Syenite penetrating the Gneiss, and in some instances in such extent as to present large protruding masses, or broad surfaces of the granitic and syenitic rocks above, as may be well seen at several points along the James river canal, and perhaps still more readily at the rugged exposures adjoining the mills on both sides of the Appomattox at *Petersburg*. In the latter locality, the bedding of the Gneiss is quite distinct, the dip varying from north a little to the east and to the west, the angle in general about fifteen degrees. Here the veins of Granite and Syenite penetrating the mass in various directions, and often intersecting one another, by causing the very unequal weathering of the rock, have given rise to its peculiar ruggedness of form. In this and the other localities, the granitic veins are at once detected by the large scales of silvery Mica adhering to the surface, or imbedded in the mass, and those of Syenite by the almost total absence of the black Mica usual in the Gneiss, and the large predominance of the Felspar over the remaining ingredient, the Quartz.

The rocks above referred to, forming the margin of the primary on the east, after extending over a breadth of some miles, are seen to give place to other modifications of Gneiss. These differ from the preceding, in having generally a more slaty structure, and being much less uniform in aspect and composition. As a group they are also more felspathic, contain much more Hornblende, are less capable of resisting atmospheric agencies, and are consequently found in a decomposed state, to a greater depth beneath the surface. Belts of Hornblende slate occur, associated with them, and in many belts the Gneiss itself is so largely imbued with Hornblende, that it forms the characteristic mineral of the rock. These Hornblende slates and Hornblendic Gneiss rocks, being less easily decomposed than the felspathic rocks with which they are associated, are frequently met with in the ravines, while the latter, though extensively indicated by the deep beds of white and ochreous felspathic clay, still retaining some traces of the previous rocky structure, are but rarely seen upon the surface. Beds and veins of Quartz are of not unfrequent occurrence amongst these rocks, and beds of a coarse description of iron ore have been found in them at a few localities.

The dip of these rocks, although for the greater part of their extent towards the SE., presents in some sections repeated alternations between that and a northwest direction, the angle in general being high.

At numerous places in the belts occupied by the highly felspathic Gneiss, the extensive decomposition they have suffered has given origin to beds of felspathic clay of great whiteness, including the unchanged particles of Quartz and leaves of Mica, originally united in the rock. This material is often of such purity as with proper preliminary treatment to form a valuable porcelain earth; and there can be little doubt that when the manufacture of the finer varieties of

pottery becomes established in *Virginia*, the tracts in question will be capable of furnishing abundant supplies of this material of a quality adapted to be thus used.

MICACEOUS, TALCOSE AND ARGILLACEOUS SLATES.

Westward of the triangular district of Gneiss rocks just alluded to we find a broad belt of more slaty rocks, which according to the peculiar ingredient predominant for the time, are either of the Micaceous, Talcose or Argillaceous character.

This belt reaches nearly to the eastern flank of the Southwest mountain, in *Fluvanna*, *Albemarle* and *Orange* counties; and farther north, though in part covered by the middle secondary rocks, there widely expanded over the corresponding region, is still traceable in considerable width east of that formation, through *Fauquier*, *Prince William* and *Fairfax* counties, as well as in narrow and interrupted tracts along the eastern base of the Bull Run and Kittoctin mountains.

As a general character these slaty strata, where adjoining the Gneiss tract, are more micaceous than farther west. Indeed the Mica slate is here seen alternating with the Gneiss over a considerable width; nor indeed are the more central or even western portions of the tract exempt from occasional and sometimes extensive ranges of certain varieties of Gneiss.

Referring, however, merely to general features, the micaceous composition, thus most strikingly exhibited towards the eastern margin of the slaty belt is seen changing as we proceed west into one in which Talc is more or less blended with the Mica, and even in some cases entirely replaces it.

These Talco-micaceous slates and Talcose slates, extensively developed in the western half of the slaty tract, include in some places beds of Chloritic slate, of Steatitic slate or impure Soapstone, and of Serpentine. But these associated rocks are rarely developed with great distinctness, and are only found over areas of small extent. For the most part they present themselves near the centre of the belt. It is in this position also that occurs the irregular and interrupted range of Chloritic Gneiss and Micaceous slate, with Chlorite, noticed in my last year's report, as disclosed in *Buckingham* county, and which displays itself in the Green Spring tract in *Louisa*. It is here, as in *Buckingham*, associated with Hornblendic Gneiss, and presents some beds of a species of Sienite, containing beautiful crystals of Epidote imbedded in pinkish Felspar.

Towards the western margin of the belt, near the base of the Southwest mountain, as well as at several points where the slaty rocks are left uncovered by the middle secondary in a similar position as regards the Bull Run and Kittoctin mountains, a larger admixture of argillaceous matter to a great extent takes the place of the Mica and Talc, thus presenting us with Argillaceous slates, still, however, retaining in some degree their Micaceous and Talcose character.

These again include strata of a more arenaceous composition, composing gritty slates, sometimes approaching the character of a sand-

stone or conglomerate, and analogous to those described in my last year's report under the name of Gneissoid sandstone or Pseudo Gneiss; and again, by a still more exclusively siliceous composition, and a finer and more nearly crystalline texture, the same slaty rocks pass into Quartzite or Quartz slate.

Throughout the whole of this belt of slaty rocks, veins and beds of Quartz are of very common occurrence, and in the Talcose and Micaceous slates especially, are frequently more or less auriferous. In fact this belt includes nearly every locality in the northern primary district in which mines have been opened for extracting gold, or in which the metal has been found; and it may be added, that its prolongation south of James river embraces the gold district of that part of the state.

Associated with these slates, and near their western margin, there occur patches or ledges of limestone similar to those described as existing under analogous circumstances in the southern district. To these more particular reference will be made under a subsequent head.

But besides the great belt of slaty rocks above described, there is another of somewhat similar character, though less distinctly marked and of much less breadth, situated westward of the range of the South-west, Bull Run and Kittoctin mountains, and lying between it and the belt of Gneiss and granitic rock previously described as occupying for a considerable width the region immediately east of the Blue Ridge. In this are embraced numerous varieties of Micaceous, Talcose, Argillaceous, Chloritic and Steatitic slates, including occasional patches of limestone, and associated at several places with extensive ledges of the Gneissoid sandstone.

Among the slaty rocks of both these belts, many beds occur of a quality fitted for the coarser architectural purposes, such as the construction of walls, steps and flagging. For these uses the micaceous gritty slates, of frequent occurrence near the western limits of the eastern belt, seem especially adapted, as well from their durability as the smooth slab-like forms in which they are separated from the quarry. The Talcose and Steatitic varieties found in the same belt rather east of the former, where sufficiently solid, are also permanent, and have the advantage of being readily dressed across the grain. All these are occasionally, though not extensively, used in building.

Among the argillaceous rocks of both belts are found ledges of a dark coloured state, having a texture adapting it to be used for roofing. As yet few quarries have been opened for this purpose, and the true value of the material, at most of the localities where seen, remains to be practically tested. One of the most interesting openings of the kind, is that situated about one mile south of the White Sulphur springs in *Fauquier* county, on the north branch of the Rappahannock river. The rock here is a dark argillaceous slate, forming a ridge close to the river, and about fifty feet in height. Its lamination is nearly horizontal, though rather irregular, dipping sometimes south by west, and sometimes south by east. Many of the seams and joints are stained of a yellowish brown by the iron deposited from the

decomposing iron pyrites, of which small crystals are seen dispersed through the rock. It is this ingredient also that produces the little knots or tubereles frequently seen on the surface of the laminæ; and thus aided by some slight irregularities of lamination, causes the rock to split, with surfaces a little rough and uneven. This range of slate extends in a northeastwardly direction for about two miles, and has been quarried at several places east of the road leading from the springs to *Warrenton*. A similar slate also appears to the west of the road and about half a mile from the springs.

In general, the soil of these belts of slate is of a grey or light brown colour, contrasting strongly with the deep red hue of that produced by the decomposition of the neighbouring Epidotic rocks. In its unimproved state it is far from being productive, but experience has shewn that it is capable of being greatly benefitted by the use of lime, of which many tracts are provided with a convenient supply in the contiguous patches of limestone.

Epidotic Rocks.—Rocks of the kind here designated, occupy the hilly tract intervening between the two belts of slaty strata above described. They compose the chief mass of the Southwest mountain in *Albemarle* and *Orange* counties, disappearing in part beneath the middle secondary rocks in the space between Racoon ford and the mouth of Robertson river, and in part prolonged across the Rapidan river at Barnett's ford, they skirt the middle secondary on the west, and as they are continued in the same general direction shew themselves extensively along the western side of the Bull Run mountain, forming most of Rappahannock and Carter's mountain, as well as of the Kittoctin mountain, throughout its whole extent.

Besides forming the characteristic material of the important belt above described, and of its continuation for some distance towards the southwest, these rocks also occupy a wide tract in many parts of the Blue Ridge, presenting themselves for the most part in the intermediate space between the Gneissoid and Granitic rocks usually met with towards the eastern base of the mountain, and the sandstones and altered rocks of formation I. lying upon its western flank, or spreading upwards to form its summit.

The rocks under consideration are distinguished by various shades of green, arising from the contained Epidote, which in many instances composes a large portion of the mass, and occasionally presents itself in the shape of distinct crystals grouped together in nests, or forming the margin of the small veins of opaque white Quartz with which the rock is always more or less penetrated. They are also remarkable for their hardness and density, but readily lose these characters as well as their colour, by exposure to the weather, becoming in this case loose and crumbly and assuming a yellowish tint, which in time deepens through various shades of orange into red.

In these highly Epidotic rocks, the traces of stratification are doubtful and indistinct, although where observed they are seemingly correspondent with the bedding of the contiguous slaty rocks. Both in the Blue Ridge and in the Southwest mountain and its prolongation, the variety here spoken of has the character of an intrusive

rock, elevated by igneous action into and among the adjoining strata. It is often Amygdaloidal, containing kernels of white Quartz and other minerals, sometimes it is vesicular or filled with small cavities, sometimes, again, it is penetrated by thin seams of imperfect Asbestus, while, as already remarked, it is very commonly traversed by ramifying veins of opaque white Quartz. All these characters bespeak an igneous origin and ally it to intrusive rocks.

As examples of the many beautiful varieties of this rock and those contiguous to it, met with at various places in the two belts just described, I may mention that between Mountain run and Racoon ford in *Orange* county, where the Epidotic rocks are widely displayed. Near the southeastern boundary of the middle secondary, they present the following varieties besides the ordinary compact green mass:

1st. Epidotic Amygdaloid.
2d. Amygdaloid with drusy Quartz.
3d. With Chalcedony and crystalized Quartz.
4th. Quartz with red and white Chalcedony.
5th. Quartz with yellow Jasper Amygdaloid.
6th. Brown Semi-Opal.

In the Blue Ridge, at Ashby's gap, where the Epidotic rocks occupy nearly the whole width of the mountain, the following varieties are seen:

1st. Light green Epidotic rock compact and fine granular; some surfaces with small brilliant crystals of Epidote.

2d. Light green Epidote with nodules or kernels of opaque white Quartz embedded in the mass.

3d. Epidotic rock, Amygdaloidal; numerous very small reddish kernels, flattened and closely contiguous, contained in a base of reddish and greenish Epidote.

4th. Green slaty Amygdaloid, consisting of numerous small nodules of Epidote disseminated through indurated Chloritic rock.

These and other interesting varieties are found associated with the Epidotic rocks at Thornton's, Swift Run, Turk's and Rockfish gaps, as well as at intermediate points, and continues to be displayed for some distance farther on towards the southwest, but in diminishing extent. At Thornton's gap and its vicinity, the Amygdaloids are of peculiar beauty, consisting of a Jaspery rock of a rich purple colour enclosing kernels of beautifully white opaque Quartz, each of which has for its centre a group of radiating crystals of bright green Epidote.

Associated with the highly Epidotic rocks both of the Blue Ridge and the more eastern tract before noticed, we meet with dark green rocks of great density, often including kernels and patches of Epidote, and evidently consisting more or less of this substance as an ingredient diffused throughout the mass, in combination with Chlorite, Talc, and perhaps Hornblende. These are always distinctly stratified, and are often found associated with gritty rocks, having the character of altered slates and sandstones. In fact, the ponderous dark green slates here referred to, pass by gentle gradations into the Argillaceous, gritty and Talcose rocks lying in their vicinity, both in the

Southwest mountain and the Blue Ridge, and from this and other considerations, are to be regarded as but modified sedimentary strata, while the unstratified Epidotic masses would seem to have been the immediate instruments in producing the change.

As remarked in my last report, of the areas in the southern districts, similarly abounding in Epidote, the soil of the tracts above described, is always of good quality, containing a marked amount of combined lime, derived from the mineral in question, and to which its productiveness may in some degree be attributed.

OF STEATITIC AND SERPENTINE ROCKS.

Various modifications of these materials are met with interruptedly in both the slaty belts above mentioned, but the tracts in which they seem chiefly to occur in the northern district are situated, first, in the eastern belt west of the middle of its breadth, in *Fluvanna* and *Louisa* counties; and secondly, near the eastern boundary of the middle secondary in *Fairfax* county towards the Potomac. They are also met with rather indistinctly characterized at various points along the Blue Ridge.

Of the range in *Fluvanna* and *Louisa* counties, it will suffice at present to remark, that it extends in variable width from the neighbourhood of *Scottsville*, nearly in the direction of the county line, east of Union mills and between *Mechanicsville* and *Newark*. Though for much of this distance, its steatitic character is greatly obscured by the presence of a large portion of Talc and Argillaceous matter, at many points the predominance of Steatite is marked, and the rock is a soapstone of moderately good quality. It is here, however, unmingled with Serpentine.

In *Fairfax* county, as we approach the Potomac, we meet with Steatitic and Serpentine rocks, especially the latter, over an area of considerable extent, evidently the counterpart of the wide tract in *Montgomery* county, *Maryland*, where the same rocks exist in great abundance. Between Difficult creek and Still House creek, the greenish Talcose slate is seen to include heavy beds of Serpentine and Steatitic rock, including several interesting minerals, among which is Chrome-iron ore. As yet, our researches in this tract are incomplete, and I am therefore unable to affirm any thing of the extent or value of this included mineral; but future observations directed specially to this point, will furnish the data requisite to form a confident opinion. The following facts in relation to the Serpentine quarry near *Dranesville*, will serve to illustrate the character of the rocks and their contained minerals.

The quarry is one and a half miles SE. of *Dranesville*, on the land of *Mrs. Sandford*. The rock which rises in a ridge about 100 yards in width, appears above the surface in ledges, and has been exposed by diggings. The Serpentine is mostly slaty, sometimes in solid layers, nearly vertical, running NNW. with a high easterly dip. Its colour is generally dark green, though sometimes light; and it is associated with Talc, Asbestus, Carbonate of Copper, Chrome-iron and

Magnetic Oxide of Iron. Some of it is Talcose and is quarried as a soapstone. The bed is exposed for a distance of about one fourth of a mile, being enclosed in greenish Talcose slate. The principal minerals found at this locality are the following:

1st. Serpentine, dark green, with small Octohedral crystals.
2d. Talcose Serpentine.
3d. Green Talcose slate.
4th. White Talcose slate.
5th. White Ligniform Asbestus on Serpentine.
6th. Greenish Ligniform Asbestus on Serpentine.
7th. Light green Asbestus, in wrinkled lamellar masses.
8th. Talc, light green, in large leaves.
9th. Chrome-iron.
10th. Green carbonate of copper, containing Asbestus and Serpentine.

QUARTZ SLATE OR QUARTZITE.

This interesting rock, of which several localities in the southern district were described in my last year's report, is found in nearly the same geological connections, but on a scale of far greater extent in the Bull Run mountain, and parts of Baldwin's ridge and Pond mountain in *Prince William* county. In approaching Thoroughfare gap from the west, after passing over the Epidotic rocks forming the red soil in the neighbourhood of *Georgetown*, we come upon the stratified Quartz slate of the mountain, with a dip varying from east to northeast of about fifty degrees. The main mountain is composed of strata from two to four feet or more in thickness, which on its west side presenting their bare outcropping edges to view from a rough broken rocky face, distinctly traceable by its white colour for many miles along the western slope and the crest of the Ridge. About two miles north of the gap, is a high peak of the mountain, composed of these bare white rocks, called Stoney Point. In the gap, the rock presents itself in a lofty rugged cliff, the fragments of which, in the form of large angular blocks, are seen in the bed and along the sides of the little stream (Broad run) that here cuts throught the Ridge.

In the main mass, some of the layers are from 6 to 12 inches thick. They are generally Micaceous, especially the surfaces of parting. Towards the eastern side of the Ridge, the Mica is more abundant, and the rock here separating with surprising regularity into large slabs, often less than two inches in thickness, presents a brilliant coating of silvery Mica. At some points it displays a tendency to disintegrate, forming a beautifully white and sharp sand, but in general it is compact and almost crystalline, and of unquestionable durability. A little east of the mountain and separated from it by a narrow plain, occurs a small ridge composed of similar materials, at the the eastern foot of which we come upon the middle secondary.

This range of Quartz slate, the most extensive in the state, and the only one of importance in the northern district, becomes an object of curious interest, not only from the beautiful regularity of its cleavage,

and the lustrous surfaces of many of the slabs, but from the consideration that it furnishes a striking example of one of the extremes of composition among the slaty rocks, in which, instead of the usual Talcose, Micaceous and Argillaceous mixtures, we have an almost exclusively siliceous mass—of which the parts, though doubtless originally deposited as sediment, are now united with almost crystalline compactness.

PSEUDO GNEISS OR GNEISSOID SANDSTONE.

The class of rocks referred to under this head, and of which, as disclosed in numerous extensive exposures in the southern district, a somewhat minute account was given in my last report, occurs under similar geological relations in the district of which I am now treating, being found within or adjoining the belts of slaty rock before described, and near the great Epidotic range of the Southwest mountain and its prolongations.

East of the tract of Epidotic rocks, or more properly, where these become blended with the slates of the eastern belt, several ledges or narrow beds of a Gneissoid grit are met with, consisting of coarse particles of Quartz, with some Mica, and little or no Felspar. Being generally divided by smooth and regular joints, they are easily separated at the quarry in the form of prismatic blocks and thick slabs, and being durable and of a light grey colour, are not unfrequently used for steps and sills and other similar purposes. Exposures of this rock may be seen at intervals along the eastern base of the Southwest mountain, adjoining and even among the Epidotic rocks, from the Rivanna to the neighbourhood of *Gordonsville*, thence to the vicinity of *Montpelier*, where it is seen associated with a bed of limestone and marble, and adjoining Epidotic rocks and Micaceous and Talcose slates.

We meet with a belt of the same description of rock about three fourths of a mile eastwardly from *Warrenton* in *Fauquier* county, in a similar position, associated with Epidotic slates and Trap, and contiguous to a range of Talcose slates on the east. It is here exposed over a considerable extent, and has been quarried for the use of the neighbourhood.

But the most extensive beds of these Gneissoid sandstones and grits are met with near and among the Epidotic rocks adjoining the western belt of slates. This also is the position in which they are chiefly found in the southern district, where, as mentioned in my last report, they present themselves in strata of great thickness and extent near the western side of Carter's and the Green mountain.

At the western base of Watery mountain, four miles west of *Warrenton*, a range of these rocks, consisting of a grey sandstone occurs adjacent to Chloritic slate. The bed has the usual northeastern direction and steep dip towards the southeast, and furnishes an excellent stone which is quarried for building purposes and for flagging. The rocks of Watery mountain, and most of the space thence to *Warrenton*, are more or less of an Epidotic composition. Similar Epidotic

and Chloritic rocks extend westward of the belt of sandstone, so as to form the mass of Carter's mountain and Rappahannock mountain, along the western flank of which, on Carter's run, we find another and quite extensive belt of the Gneissoid sandstone, grey, hard, and very siliceous, in strata several feet thick, and associated with Chloritic slate.

In the same vicinity occurs an interrupted range of limestone, such as we find in numerous other instances near or adjoining to the Gneissoid rocks. These strata again present themselves at the eastern base of the Rappahannock mountain, where also they are quarried.

In the range of the beds above alluded to, in a southerly and somewhat westerly direction, we meet with gritty Micaceous slates and Gneissoid sandstones and grits, occasionally presenting massive strata of a character adapted for use, as in the vicinity of *Jefferson*, but most usually in a decomposing state. These cross the Aesthan river above Muddy run, and are discovered at intervals thence on to the neighbourhood of *Charlottesville*, maintaining the same general position in relation to the epidotic belt, but expanding as they extend towards the southwest, and amply exposed as formerly described in *Albemarle* and part of *Nelson* county.

Lest the statement above made of the occurrence of these gritty rocks among beds containing Epidote, should be misconceived, I would here remark, that although the greater part of the rocks composing the Southwest mountain, and its prolongations, are distinguished by a greenish colour, and include more or less of Epidote in their composition, the amount of *true Epidote rock* is comparatively small. The other and more abundant masses, upon close inspection, prove to be various slaty and gritty rocks, containing more or less Talc, Mica, and Chlorite, and impregnated in various degrees with Epidote, either in a diffused condition, or in nests or kernels, and frequently associated with small veins of Quartz. In many instances the impregnation is so slight as to produce little effect upon the colour of the mass, and the character of a Micaceous or Gneissoid sandstone is in a good degree preserved. The rocks in question, though intersected by numberless joints, in general display their stratification with tolerable distinctness, except in the neighbourhood of the bright green epidotic masses, when the planes of bedding are almost obliterated, and the rock partakes of the structure as well as the hue of the Epidote. In view of these facts, there can be little doubt that the strata referred to are but portions of what was originally one wide belt of slates and gritty rocks, which has been invaded from beneath by the igneous epidotic masses characterising the range of the Southwest mountain and its prolongations, and that the peculiar hue and texture they present, is to be ascribed to the modifying actions to which they were thus exposed.

MICACEOUS AND TALCOSE LIMESTONE AND MARBLE.

Associated with the slaty rocks of the belts already described, we meet with patches, and sometimes prolonged beds of Micaceous and

Talcose limestone, passing in some instances into a rock of a grain so fine and uniform as to constitute a variety of marble.

As in the case of the beds of similar materials met with in the southern district, these are in no case to be regarded as continuous for a long distance, but are evidently included masses of a lenticular or oval form, lying in certain belts of the slaty rocks, but not necessarily connected with one another. As will appear in the description of localities about to be presented, this included position is sometimes evinced not only by the meeting of the bounding strata of slate or other rock at the extremities of the limestone bed, but by their coming together in like form *above it*, thus shutting it out from the surface view, and allowing it to be disclosed only where a ravine or other natural or artificial section removes the incumbent rock.

The following brief account of the exposures of these limestone beds in the northern district, while embracing those of most importance, is not to be understood as including all within its limits. The unfinished state of our researches in many parts of this region, does not admit of a more full enumeration at present. It is quite probable that other localities will be discovered during the explorations of the coming season, at the same time several of those already known will claim further examination.

The range of slaty rocks containing imbedded deposits of limestone, which in my last report was described as making its appearance from beneath the middle secondary, west of *Scottsville* in *Albemarle* county, and thence pursuing a nearly northeasterly course, shewing at intervals these included calcareous masses on Buck island, Limestone and Mechump creeks, is continued in the same general direction, displaying a bed of limestone about one and a half miles east of *Gordonsvllle* in *Orange* county, and again on the farm of *Mr. Rawlings*, about half a mile southeast of the meeting house situated on the road from *Gordonsville* to *Orange* courthouse.

At these localities, the rock is dark blue and slaty, presenting smooth Talcose surfaces, and occasional thin veins of calcareous Spar.

West of the former locality, and between it and *Montpelier*, we meet with a bed of marble, bearing a striking resemblance to the rock described in my last report as shewing itself extensively on the James river opposite to *Warminster*. It is white, shaded with pink, with an occasional stain of green Talc. Being of fine grain, and exposed in a solid mass of about thirty yards in breadth at the locality now in view, it would seem to claim attention as a resource likely to be of economical value, and will on this account claim a more minute examination than in a cursory visit we were able to bestow. This bed, which obviously lies considerably west of the range of calcareous masses previously referred to, is contiguous to layers of Gneissoid sandstone, Talcose slate and Epidotic rocks.

Exposures of the calcareous rock, some of them of considerable extent, are again met with on the Rapid Ann river, nearly in the general line of bearing of those above referred to. The most westwardly of these occurs nearly opposite the mouth of Summerduck creek *on the land of Mr. Pannill.* The river being skirted on the south

side by a band of the middle secondary rocks, extending inland about a quarter of a mile, the slates and included limestone are first seen along the southern margin of these rocks.

This limestone is pinkish and sometimes grey, fine granular and sparry, dividing into layers of an inch or two and not solid. It burns into a white lime, and has been used for domestic purposes and for building.

Lower down the river, and beyond the termination of the narrow strip of middle secondary above mentioned, there occur two other ledges of limestone of very considerable extent. The uppermost of these is found about a mile above the mouth of Brooke's run, and is met with inland and in the river cliff. In the former position it is just east of the edge of the red sandstone; in the latter, the red sandstone is seen to overlap the western side of the band of limestone. The rock at the former point is mostly blue, fine granular, with much calc. Spar, and occurs in layers and masses several feet thick, presenting little or no Mica, Quartz, or other impurities. The exposure on the river has a width of about twenty yards. The strike or range of the beds is between NE. and NNE., and the dip very high southeasterly. Here the rock is blue, variegated with pink, containing much white Spar, and also narrow layers of white Quartz, which project above the weathered surface of the bed. About three hundred yards eastward of this is another and larger bed, about forty yards thick, where exposed in the river bank. It is blue and slaty, coming out in thin layers. In range and dip it agrees with the preceding.

Pursuing the same general direction, we meet with the limestone again on Mountain creek near its mouth, and on the Rappahannock at the mouth of Marsh run; the former in *Culpeper*, the latter in *Fauquier* county. At both localities the rock is exposed rather extensively, and has been quarried and burnt by *Captain Roberts* and *Mr. Whitely*. It is a bluish veined limestone, slightly Talcose and Micaceous, and of slaty structure.

The more western of these Calcareous beds, that on Marsh run, continues up the stream and shews itself at the distance of a mile from the river, beyond which it has not been observed. A little farther towards the northeast, the range of this and the more eastern limestone bed on Mountain creek, would strike the margin of the middle secondary rocks, and if continued in their original bearing, would thereafter be concealed from view by the overlying strata. After this disappearance of the limestone, occurring between Marsh run and Elkton, no beds of Calcareous rock have yet been discovered throughout all the slaty tract bordering the middle secondary rocks, thence on to the Potomac.

Similar interrupted ranges of limestone shew themselves in *Fauquier* and *Loudoun* counties, associated with the slaty and Gneissoid strata west of the principal belt of Epidotic rocks before described.

One of the most prolonged of these may be traced along the western base of Rappahannock mountain, and thence on to the neighbourhood of White Plains, shewing itself on the estates of Mr. Nelson,

Mr. Grigsby, *Mr. Baker* and *Dr. Horner*. The rock varies in colour and texture, being sometimes of a light blue tint and close grained, and sometimes of a light grey, with films of Talc on the separating surfaces. At *Mr. Grigsby's*, it is associated with green chlorite slate, and is evidently not interposed as a parallel bed, but rather as an enclosed mass, which does not rise uniformly to the surface.

At several points in this range, and especially at *Mr. Baker's*, the limestone is quarried and burnt quite extensively, and yields a lime which, though not very fair, is found to be well adapted for domestic, agricultural and building purposes.

Farther towards the northeast, a narrow bed of limestone occurs near Dover mill, on the Little river, about two miles westward of *Aldie*, associated with Micaceous and Argillaceous slates, and a little west of the Epidotic range. Beyond this, in the same direction, are several exposures, north of the road leading from *Aldie* to Snicker's gap, among which may be mentioned the quarries of *Mr. Luckett* about three fourths of a mile northwest from the junction of the road just mentioned and that leading obliquely across the Kittoctin mountain, to Oatland mills, and that of *Mr. Wethered*, more towards the northwest and near Goose creek.

At the former, the body of rock exposed is about twenty feet in width, and very indistinctly stratified. It is a fine, granular, blue limestone, not very solid, and making a moderately white lime. A little white silvery Mica occurs occasionally in the seams and on the surfaces of the rock, but not sufficient to entitle it to be called a Micaceous limestone. It is associated with greenish Micaceous Talcose slates. The rock at *Mr. Wethered's* is in the main of similar character, though said to furnish a lime of fairer complexion. Several small ledges of limestone occur in the vicinity of the above, associated with green and whitish Talcose and Micaceous slates.

Other small beds of limestone are known to occur at several points in the same general belt, between the above exposures and the Potomac river, but with the exception of those at Taylortown on Kittoctin creek, about three miles from the river, they remain yet to be examined.

At Taylortown the calcareous masses are enclosed in greenish slaty Talcose rocks, containing iron pyrites, and magnetic oxide of iron in small octahedral crystals, with some whitish Tremolite Actynolite in greenish fibrous masses and a little Asbestus.

The most easterly of these beds consists of a bluish limestone, much of which is shaded or striped with lighter and darker tints irregularly disposed over the surface; and from this, as well as its texture, deserves to be regarded as a pretty variety of *marble*. At the quarry opened on the side of the hill, about thirty or forty feet above the creek, the body of limestone exposed is about ten feet thick, and rather diminishes than increases in descending. The green indurated Talcose slate adjoining it on both sides, bends over and covers the limestone on the top, so that there is several feet of slate between it and the surface, thus affording an interesting example of that inclusion already mentioned, characterizing these limestone masses gene-

rally. A similar rock, the continuation of the former, is also quarried at the mill.

West of this, and separated from it by about twenty feet of hard green slaty rock, are several layers of *beautifully white marble*, of an admirably fine and uniform texture. The layers are solid, free from veins, and would seem capable of being extracted in masses from one to two feet thick and several feet in length. Were the deposit of greater extent, preserving the colour and texture of that now exposed, it might prove of high value for the finer uses to which this material is applied, having the pure tint, and the fine, even yielding grain of marble alabaster. It should be added that both this and the blue variety appear to be susceptible of a good polish.

Of the chemical composition of the limestones collected at the various localities above described, a detailed account will be given in the concluding chapter of the present report. On this head I need only remark, that like those met with under similar circumstances in the southern district, and of which a minute description was given in my last report, although in general less free from earthy admixture than the limestone west of the Blue Ridge, they furnish a lime capable of being very usefully applied in agriculture, as well as for household and building purposes; and that as regards the first of these applications, they deserve to be considered as a valuable source of improvement to the soils of the prolonged belt in which they occur.

In the brief sketch that has now been given of the Primary and Metamorphic rocks of a considerable portion of the northern district, I have confined myself to such particulars as could be most readily presented in a compendious form, and as had been slightly or not at all alluded to in preceding reports.

To the numerous details in my possession, omitted in this sketch, are to be added the results of the farther researches necessary for the completion of our labours in this portion of the state, in order to enable me, in my final report, to present a minute and comprehensive picture of its geological structure and important mineral contents.

As formerly remarked, an important portion of the northern district is occupied by a class of rocks entirely different from the Primary and Metamorphic masses I have been describing, and which constitute the middle secondary formation of this part of the state. These I will now proceed to describe.

CHAPTER V.

OF THE MIDDLE SECONDARY SANDSTONES, SHALES AND CONGLOMERATES OF THE NORTHERN DISTRICT—EAST OF THE BLUE RIDGE.

SECTION I.

GENERAL FEATURES OF THIS FORMATION.

The close resemblance existing between the strata of the middle secondary formation as presented in the region now under considera-

tion, and that south of the James river, was referred to in my last year's report, while treating of the southern district, and the general description of the middle secondary rocks then given, was designed to apply as well to the northern as the southern tracts in which they are developed. It will therefore be unnecessary in this place to repeat these descriptions in detail, and it will suffice before entering upon the brief sketches that are to follow, in a few words, to remind the reader of the general character of these rocks, and to point out one or two particulars in which, in some parts of the northern tract, they present peculiar features.

In the first place these strata are all of the sedimentary character, consisting of particles of sand and earth and pebbles of various dimensions, derived from pre-existing rocks, and deposited by water in the positions they now occupy in the masses of which they are the component parts. Through all the variety of texture, commencing with the coarsest conglomerates including pebbles of many inches diameter and passing by successive steps to strata composed of finer and finer materials, constituting the sandstones, slates and shales of the formation, we meet with unequivocal proofs of this aqueous origin, and at the same time, unless in certain localities where subsequently to their deposition they have been invaded by igneous rocks from beneath, we find no indications of their having been subjected to those modifying agencies, due to igneous causes, from which the metamorphic rocks of which I have been treating in the previous chapter have derived so much of the character they now present.

Though of various tints, comprising grey, brownish grey, greenish grey, brownish yellow and others, these strata as a group are marked by the predominance of a red colour, which is however more particularly prevalent among those of a shaly texture.

With a few local exceptions, their dip is to the north of northwest, and the inclination, though variable, is usually small, thus conforming precisely to the position of the corresponding rocks in the southern district.

They here also, as in that part of the state, contain impressions of vegetable stems and leaves converted into Lignite and coaly matter, and in a few localities they preserve distinct traces of the remains of fish, especially the well characterized rhombic scales mentioned in my last report as discovered at several points in the middle secondary rocks of the southern district.

The coarse conglomerate or breccia is met with here, as in the southern district, chiefly along the western margin of the formation, but with this peculiarity, in the neighbourhood of the Potomac and one or two other points, that a considerable proportion of the imbedded pebbles consist of limestone—thus converting the mass into the rock well known under the name of Potomac marble. As indicating the cause of this local peculiarity of composition, besides referring to what was said on the subject in the report of last year, I may observe that in *Maryland*, not far from the Potomac, an extensive range of *limestone* displays itself a little eastward of the margin of the *conglomerate*, the more eastern portion of the middle secondary rocks,

which by their position would have rested upon this limestone, being wanting over a considerable space, and that this limestone in its prolongation towards the southwest, disappearing beneath the middle secondary rocks, before reaching the Potomac, is in all probability continued for some distance in this buried position near the eastern margin of the conglomerate. In such a view, the source of the calcareous fragments contained in the conglomerate met with near the Potomac, would be no less apparent than it is in other positions where beds of limestone are met with along the eastern margin of the middle secondary belt.

Referring for farther details in regard to the various characteristic features of the formation, to my report of last year, I proceed to give a compendious account of its boundaries, and some of its component strata, as it displays itself in the northern district.

SECTION II.

BOUNDARIES OF THE MIDDLE SECONDARY FORMATION IN THE NORTHERN DISTRICT.

Before proceeding to describe the boundaries of the formation, it is proper to remark that, as with the exception of one short interval near its southern extremity, it is continuous from the Potomac to that point, it will be most convenient to describe the whole in one connection—reserving the special account of the boundaries along the deficient space, which are yet not precisely settled, for the more minute delineation hereafter to be given. I would also remark, that although in thus briefly tracing the outline of the area in question, reference will be made only to points most easily recognized on the map, and often, therefore, at very considerable distances apart, the greater portion of the boundary has been explored at much smaller intervals, so that with the exception of some miles between *Leesburg* and the Potomac, in the neighbourhood of Noland's ferry, and several short lines towards the southwest, the limits of the area have been accurately traced. I may therefore be allowed to repeat the suggestion made in my last report, that the reader desirous of having a distinct picture of the position and form of this important portion of the northern district, should follow the description here given, pencil in hand, and thus trace for himself an approximate outline of the region on the map.

The general form of this area is that of a prolonged triangle, extending in a direction from SSW. to NNE. having its apex at the southern extremity, and gradually expanding until it reaches the Potomac. Measured from the apex to a point on the Potomac, midway between the mouths of Goose creek and Broad run, its length is about eighty miles, but including the narrow tract extending northwardly from *Leesburg* to the neighbourhood of Noland's ferry, it would be increased to near eighty-eight miles. Its greatest breadth, as measured near the Potomac, and parallel to the road leading from *Leesburg* to *Dranesville*, is about fifteen miles. This, in round numbers, gives *six hundred square miles* for the area of the middle secondary region in *the northern* district.

Beginning at its southern extremity, about a mile SW. of *Barboursville* in *Orange* county, the boundary of the small area lying to the southwest of the interruption above alluded to, may be traced by a line drawn a little east of the upper part of Blue run, and parallel to the stream as shewn on the map, until this line passes the mill below Brewer branch, continuing in the same direction parallel to the SW. mountain, so as to pass a little west of Montpelier, and striking the turnpike leading from *Orange* courthouse to *Stanardsville*, at the eastern crossing of Poplar, *alias* Baylor's run, thence bending around towards the northwest, so as to strike the Rapidan river at a point not yet determined, near the mouth of Poplar run, then turning towards the southwest, passing in that direction a short distance east of the mill where the turnpike touches the river, continuing on a little westward of the meeting house, and of *Barboursville*, and thus returning to the point at which the tracing was commenced.

As already mentioned the interval between this and the principal tract lying to the NNE. has only been partially explored, and I am therefore unable, with precision, to lay down the position of the boundary of that portion of the tract southeast of the junction of the Robertson and Rapidan rivers. Much of the interval is occupied by the Epidotic rocks forming the prolongation of the Southwest mountain, which are continued in considerable breadth to the neighbourhood of Racoon ford, and at the same time extending in a northwestwardly direction across the Rapidan at Barnett's ford, send out a spur, or another but interrupted range, seen at intervals thence towards *Culpeper* courthouse. For the present considering the boundary of this part of the tract as coinciding with the course of the Rapidan river, from the mouth of Robertson river to a point a little above Racoon ford, the eastern margin of the principal area may be traced by a line drawn through the points and in the directions described below.

Commencing at a point on the south side of the Rapidan, about three fourths of a mile above Racoon ford, its course nearly due east diverges slowly from the river until it touches the road between a half and three quarters of a mile towards the south; it then bends a little northwards and curving around so as to strike the river about a mile above the mouth of Brook's run, where the limestone and middle secondary are seen in contact, it crosses the Rapidan in a northeastwardly direction, passes Brook's run a short distance above its mouth and intersects the road leading from Germanna ford to *Stevensburg*, at a point a little west of the fork near the meeting-house laid down on the map. Thence bending slightly more towards the north, it crosses Mountain creek near the second mile above its mouth and strikes the north fork of the Rappahannock, a short distance above the mouth of Marsh run. Now pursuing a course almost due northeast, it strikes the head of Elk run a little distance east of *Hickerson's* at the cross roads, and turning rather more towards the north passes west of *Brentville* and east of *New Market*, so as to cross the turnpike from *Centreville* to *Warrenton* near the western verge of the former. From *Centreville*, continuing in nearly the same direction, it intersects the turnpike leading from Alexandria to Winchester, about

four and a half miles westward of *Fairfax* courthouse, and thence prolonged crosses the road from *Georgetown* to *Leesburg* at *Dranesville*, situated on that road due south of the upper end of Beech island as laid down on the map. Continued from this point, it strikes the Potomac river at a point not yet precisely ascertained, about one or two miles below the mouth of Seneca creek in *Maryland*. Of its prolongation in *Maryland*, it will be enough to say, as supplementary to the tracing just given, that after crossing the Potomac it quickly bends around to the north and then to the northwest, so as to pass over the Seneca between the mouths of the Dry and Little Senecas, and to intersect the Little Monocacy, some distance above its mouth, whence turning to a northern and afterwards a NE. course, it crosses the Big Monocacy very obliquely, and shews itself on the Baltimore and Ohio rail-road, immediately west of the limestone before referred to, evincing in the remarkable change of its course, after crossing the Potomac, the great contraction of the middle secondary area, which was mentioned in the same connection as occurring in this region.

Returning now to the southwestern extremity of the tract for the purpose of tracing its western margin, we find it marked out by a line passing through the points and having the directions enumerated below.

Beginning at the mouth of Robertson's river, its course, though not yet minutely ascertained in this vicinity, is such as to intersect Cedar run a little eastward of where that stream crosses the road leading from *Fairfax* (*Culpeper* courthouse) to near the mouth of Crooked run. Thence it continues so as to strike the road in question about two and a half miles south of *Fairfax*, and passing a little west of the village, extends to Muddy run near the principal bend. From this point, its course, though not exactly determined, carries it across Aestham river, near the mouth of Muddy run, and Hedgeman's river, a little below Freeman's ford, and thence on to a point on the road from *Warrenton* to *Elkton* about one hundred yards west of Turkey river. Pursuing the same direction until it passes the southern end of Baldwin ridge, it curves around so as to take a more northerly course, and keeping close along the eastern flank of Baldwin ridge and Pond mountain, crosses the road leading through the gap, about one mile eastward of *New Baltimore*. Thence continuing its course along the eastern flank of Pond mountain, it intersects the road leading to *Georgetown* by Thoroughfare gap, about a quarter of a mile east of the mill at the eastern end of the gap. Extending along the base of Bull Run mountain, in a nearly uniform course, it crosses the Aldie turnpike about a fourth of a mile east of the village, thence runs nearly parallel with Little river for some miles, and passes Goose creek at Carter's mill, (Oatland mills on the map,) and adhering closely to the flank of Kittoctin mountain, passes a little west of *Leesburg*, touches Limestone creek near its head and in the vicinity of Matthew's store, about six miles NNE. of *Leesburg*, and thence continues to a point not yet determined in the neighbourhood of Noland's ferry on the Potomac. Its extension in *Maryland* preserves a course nearly parallel to the Monocacy river, and to the eastern boundary line before traced, after

that line has crossed the river, the two being thus made, in this part of their course, to comprehend a very narrow tract, chiefly occupied by the calcareous conglomerate.

SECTION III.

CHARACTERS AND CONTENTS OF THE STRATA AND OF THE ASSOCIATED TRAP ROCK.

The chief peculiarities of the middle secondary strata in the tract now under consideration having already been alluded to, and their more important varieties as to texture, colour and contents, having been described in the report of last year, when treating of the similar materials of the middle secondary tracts in the southern district, I shall content myself with only a few additional illustrations, drawn from localities within the area of which I am now treating, and as for the present, these admit of being most easily presented in the form of brief summaries of the several varieties of rock met with in passing across the region at various points, I shall introduce them in that shape.

In entering upon these descriptive sections, it should be premised that the protruding masses of igneous rock, of the nature of Trap, met with even more frequently in this than in the southern tract, constitute, in a geological point of view, one of its most interesting features. These intrusive rocks, which, forced up from beneath by igneous agencies, have penetrated either partially or entirely through the middle secondary strata, are readily distinguished from the enclosing sandstones, slates and shales, by their dark grey and nearly black colour in the interior, and the ochreous brown hue they assume when weathered, by their great hardness and heaviness, and by their not appearing in regular strata, but in knobs and ridges, breaking down by exposure into masses of a rounded form, from a few inches to several feet in diameter.

These knobs and dykes, though not usually of great extent, are exceedingly numerous in many parts of the tract, giving a ruggedness to the surface which it would not otherwise present. Where appearing in the form of true dykes or walls of Trap, rising through the adjacent strata in a nearly vertical direction, they may sometimes be traced longitudinally for a distance of a few miles, and are then seen to have directions, which, though by no means regular, are generally towards the west of north. But few instances, however, occur, of their being prolonged with sufficient distinctness to admit of determining their bearing in a satisfactory manner, and (for the most part) they present themselves as isolated knobs or short ridges, with no traceable connection on the surface.

The modifying influences of these igneous rocks upon the adjacent strata, exemplified in my report of last year, with reference to certain localities in the southern tract, are observable also in numerous places in the northern area, the strata in the immediate vicinity of the knobs or dykes of Trap, though but little disturbed in position, displaying

in such cases various remarkable changes as to texture, colour and composition. In most cases, the alteration thus produced does not extend beyond a change of colour and increased hardness and density of the modified mass, but at some localities it is marked by the development with the substance of the altered rock of various crystalline minerals, among which Epidote of frequent occurrence, sometimes distributed through the mass, but more commonly collected in the form of oval or spherical kernels, like those of an Amygdaloid. As locally illustrating the order of succession of the middle secondary strata and the mode of occurrence of the igneous rocks among them, I proceed now to a brief description of several sections as above proposed.

Taking as our first illustration the transverse line marked out by the road leading through *Dranesville* to *Leesburg*, comprising a breadth of upwards of fourteen miles, we find the middle secondary and igneous rocks to occur in the following succession :

Immediately west of the small ridge on which *Dranesville* stands and which is composed of micaceous slates, we meet with the red sandstone of the middle secondary, consisting of layers alternately hard and soft, and including some conglomerate. This continues alternating with greenish slabby sandstone and red shale, as far as Broad run. Many of the beds presented in this interval are of sufficient firmness and durability to be used in architecture, and have accordingly been employed in constructing the bridge over Sugarland creek. The greenish sandstone is of a variety met with at numerous other localities, being remarkable for containing the remains of vegetable stems converted into coaly matter, and coated in places with green carbonate of copper, the rock itself also presenting thin films and disseminated particles of this substance. At Broad run, occurs an extensive dyke of Greenstone Trap crossing the stream obliquely, with a bearing or course of NNW. and a dip of sixty degrees to WSW. At the eastern end of the bridge, it rises like a great wall, spontaneously dividing into layers from one to two feet in thickness, and presenting at the first glance the aspect of a hard Sandstone or Gneiss. Its width is about 150 yards, and on the western side it displays the usual tendency to the globular form. Beyond this, with some reddish slate, we have grey and ash coloured slaty sandstone; and about a mile before reaching Goose creek, we come upon another range of green stone, beyond which we are again presented with the reddish and light coloured shales and sandstones. At Goose creek, the green stone is repeated, forming a broad dyke running N. a little W. and nearly vertical, and in about a fourth of a mile farther on we have another dyke of the same material, about 20 yards in width, rising abruptly on the south side of the road like a solid wall. Between the two dykes last mentioned the sandstone gives striking evidences of alteration, presenting itself as a hard, compact, fine-grained rock, of a mottled and grey aspect, at first view bearing some resemblance to a green stone. It also exhibits a jointed structure conforming to that of the igneous masses in the neighbourhood, and obliterating its original stratification. Beyond this we have

altered sandstones and shales, with green stone, to *Leesburg*. Within the town is a small range of green stone, and in various directions in the neighbourhood are abundant exposures of the conglomerate. The latter rock is characterized in this part of the tract, as formerly mentioned, by the large proportion of limestone pebbles it contains, as well as the amount of calcareous matter diffused through the material by which they are cemented together. At *Col. Shreeve's*, quarter of a mile from the town, in a southern direction, it is so rich in carbonate of lime as to be quarried and burnt as a limestone, affording a lime well suited for building and agricultural purposes.

Taking as another illustrative section, the line of the turnpike road leading from *Fairfax* courthouse to *Aldie*, we leave the red micaceous slates of the primary region about four and a half miles westward of the courthouse, and immediately enter upon the middle secondary tract. The rocks here are red sandstones, of moderately fine grain, in compact layers of sufficient hardness and durability to be valuable in building. These continue for some distance, occasionally alternating with red shales and brownish sandstones; and at about six miles from the courthouse we meet with the greenish sandstone containing vegetable stems converted into coal, which, as well as the rock itself, is sometimes stained by carbonate of copper. Next we meet with a small dyke of greenstone Trap. Thence we pass to red and brown micaceous sandstones of fine grain, and these, with occasional beds of similar colour but coarser texture, together with several small ranges of green, occupy the next four miles. The rocks are now observed to become more soft and shaly, and continue with this character until within about three and a half miles of *Aldie*, when we meet with the coarse conglomerate usually found near the western margin of the tract. Beyond this, we have the red sandstone again for a short space, then a range of globular greenstone, followed by soft red shales, containing hard layers of sandstone; after which, occur two more ridges of greenstone, with a small interval occupied by soft red and green shales; and finally, a width of about one hundred yards of these shales form the western margin of the middle secondary about one fourth part of a mile east of *Aldie*.

Referring next to a section in the line connecting *Elkton* and *Warrenton*, still beginning our observations at the eastern boundary, we find at the former point associated with the red, brown and grey sandstones, a dense slaty sandstone of an olive green colour, smoothly laminated and of remarkably fine grain. These red, brown and grey rocks continue for about one mile, when we come upon a range of green stone running north and south, two hundred yards in width. This rock is coarse, consisting of greenish Hornblende and white Felspar, both quite distinct, and the latter in some specimens so abundant, as to give the mass the appearance of a Sienite. Beyond this, the sandstone is dark green and slaty, bearing marks of having suffered some alteration from its proximity to the igneous mass. This is succeeded by red shale, which soon gives place to another range of *green stone* much decomposed and weathering in the globular concentric form. We now have green slaty sandstone followed by red

sandstone and red shale, which with the addition of another small range of green stone occupy the remainder of the distance to *Germantown*, (Shumate's) near Licking run. Here we are presented with the igneous rocks on a more extensive scale, not in the form of a regular dyke or ridge, but as a number of protruding knobs or short ranges sometimes seen to coalesce with one another. The rock displays much variety of composition at different points. Towards its western edge it consists of globular concretionary masses of a dull greenish colour, imbedded in a paste of similar aspect and composition. It here contains nodules of Chalcedony, enclosing crystals of Quartz, some of the Chalcedony being disposed in numerous layers slightly varying in colour and thus forming a species of Agate. From this onwards the red sandstone and shale, with occasional bands of greyish and greenish sandstone, continue to within four miles of *Warrenton*, where the igneous rock again appears in considerable force, crossing the road seemingly in detached ledges for a distance of half a mile. Terminating on the east side of Turkey run, it is followed by a narrow strip of the red sandstone on the opposite bank, which here forms the western margin of the middle secondary rocks, about three and a half miles from *Warrenton*.

As indicating the character and succession of the strata still more towards the south, an oblique section passing from the eastern margin near the Fork meeting-house, through *Stevensburg* to *Fairfax* (*Culpeper* courthouse), will serve to complete the illustrations on this head, as far as they can with propriety be presented at this time. Commencing at the point above mentioned, which is about six miles eastward of *Stevensburg*, after quitting the micaceous and other primary slates, we come upon the red shales of the middle secondary. These are soon followed by greenish and bluish slates, fine grained, compact and hard, and separating in slabs suitable for building. To these succeed red shales and sandstones, generally of fine texture, with which are associated bluish and greenish sandstones and shales, frequently calcareous, and in some layers consisting of shot-like grains, containing a marked amount of carbonate of lime, and slightly filmed with green carbonate of copper. Within about one and a half miles of *Stevensburg* we encounter a dyke of green stone, of the variety commonly called Iron stone, of coarse grain and great hardness, and separating in large spheroidal masses. Adjoining this, the shale is of a greenish or olive hue, and greatly indurated. Similar altered rocks continue for most of the distance to *Stevensburg*, presenting in some of their layers spots and distinct concretions of semi-crystalline matter of a lighter colour than the enclosing mass—evincing, even more strikingly than the increased hardness and heaviness of the rock, the modifying agency of igneous causes. Proceeding westwards, we have frequent alternations of bluish and red shales, as far as *Georgetown*, before reaching which, and just opposite the foot of Mount Poney, we meet with the anomaly of a northeastern dip among these rocks. Beyond *Georgetown* the shale, continuing its eastern dip, exhibits striking marks of alteration, having nearly the hardness of Hc stone, being specked with semi-crystalline matter, and so interw

with joints as almost to obliterate its stratification. This is soon followed by heavy beds of conglomerate, chiefly made up of huge pebbles, sometimes six inches in diameter, consisting of Epidotic, Chloritic and other rocks of the primary region, imbedded in reddish shaly matter. These alternating with red shale and sandstone continue to the courthouse.

In connection with these details, it is proper to mention tha similar marks of alteration from igneous causes, are observed in nearly all the middle secondary rocks lying in the tract between *Fairfax* and Racoon ford. Indeed, in many instances, their semi-crystalline texture, density, dark olive green colour, and tendency to vertical cleavage, and something approaching to columnar form, give them at first view the aspect of some of the igneous rocks to whose agency they are no doubt indebted for the curious modifications they have sustained.

In alluding to the contents of the middle secondary strata in the various sections briefly described above, mention has been made of the occasional occurrence of coaly matter and of an ore of copper among them. In several localities the former has been met with, associated with a black wafery slate, having much the appearance of the shales often found adjacent to seams or beds of coal. This fact, taken in connection with the general resemblance of the middle secondary strata to those accompanying coal in other regions, has given rise to the opinion that valuable deposits of that substance are to be found among these rocks, and has led to explorations by means of diggings at various points where, from the dark colour and bituminous character of the slates, the object sought for was thought most likely to be concealed. In regard to this expectation, I feel called upon to remark, that after much careful observation, at the points where openings have been made, as well as elsewhere among analogous strata, and after an attentive inspection of the middle secondary rocks throughout the entire tract, I see no ground whatever for anticipating the discovery of any true coal seam within its limits, and that, as in the case of the southern tracts referred to in my report of last year, the coaly matter occasionally associated with these rocks, is contained in them only as derived from the vegetable remains scattered through some of the layers, or as films or thin seams of merely local extent.

Hopes not less sanguine than those above alluded to, have likewise been excited by the existence of the carbonate and other compounds of copper in the shales at several localities, and mining enterprises of no inconsiderable extent have been undertaken to explore the strata for these materials. But at none of the openings thus made, and in no parts of the middle secondary tract where the ores of this metal have been met with, have they presented themselves in sufficient quantity or in proper form for advantageous mining. Besides the green carbonate already mentioned as of frequent occurrence in the shape of films and specks, often associated with vegetable impressions, and contained in calcareous shales, the phosphate and sulphuret have also been met with at several localities, but though sometimes in sufficient amount to furnish cabinet specimens of great beauty, the diffused condition in which they have thus far always

presented themselves, furnishes no reasonable ground for the hope of meeting with them in a regular vein or deposit, likely to be of economical value.

CHAPTER VI.

EASTERN DIVISION OF THE SOUTHERN PRIMARY DISTRICT AND THE COAL FIELDS OF CHESTERFIELD, POWHATAN, GOOCHLAND AND HENRICO COUNTIES.

Our observations in the portion of the primary region lying south of the James river, not previously explored, here conducted by means of numerous transverse sections, extending from the eastern boundary of the primary rocks to a line passing through *Cumberland*, *Prince Edward*, *Charlotte* and *Halifax* courthouses, this line marking the general eastern limit of the explorations of preceding seasons. Combining with these the examinations made at intervening points, and connecting the whole of the results thus obtained with the minute investigations of former seasons in the western division of the southern primary tract, we are furnished with all the materials necessary for forming as correct a picture as need be desired of the geology of this widely extended area.

As an important part of our observations in the district under consideration, and in that adjacent to it on the north, some time was devoted to the determination of the boundaries of the coal region in *Chesterfield* and *Powhatan* counties, and of its counterpart on the north side of the river in *Henrico* and *Goochland* counties, as well as of the small tract lying more towards the northeast, formerly referred to as the Dry run basin; and in addition to these observations, chiefly confined to the margin of the areas occupied by the coal-bearing rocks, several sections were made across these tracts, and various details collected in regard to the workings now in progress, not previously obtained.

Omitting at this time a particular account of these observations, as being for the most part unintelligible without the aid of a geological map and sections, I propose first, to describe briefly the course of several of the more important lines of section explored in the region on the south side of James river—stating in few words the prevailing characters of the rocks exposed; and secondly, to trace the outlines of the coal districts with as near an approach to accuracy as can be attained by referring to the state map.

The first section commences at Falling creek on the *Buckingham* road, and extends by *Powhatan* courthouse to *Cumberland* courthouse. The first eight miles nearly of this distance is across the coal field, presenting therefore no rocks but the sandstones, grits and slates of the coal measures. Beyond this, we have numerous alternations of Gneiss, Granite, Seinite, Hornblende Slate, Hornblende Gneiss, with occasional beds or dykes of Trap, and veins and beds of Quartz.

The dip, among the stratified masses, towards the southeast, and generally at a high angle. This connects with a section previously constructed, from *Cumberland* courthouse through *Maysville*, *Warminster* and *Lovington*, to the western side of the Blue Ridge at Tye river gap.

The second section extends from *Petersburg*, by *Amelia* courthouse, to about three miles beyond *Ligontown* on the Appomattox river. This line of observation, lying a little south of the southern end of the coal field, is at the mouth of Winticomack creek, does not contain any of the coal rocks, but displays a broad band of primary slates a little east of what would have been the extension of the coal field. In other respects the rocks presented along the section agree in general character with those of the preceding.

The third section commences at a point on the Petersburg and Roanoke rail-road, about ten miles south of *Petersburg*, and passing through *Dinwiddie* courthouse and *Nottoway* courthouse, terminates at *Prince Edward* courthouse. The rocks chiefly met with are Gneiss, Seinite, Hornblende, Slate and Trap, together with the extension of the band of primary slates noticed in the last section, which is here contracted to a much less width.

This connects itself with a section previously formed, extending from *Prince Edward* courthouse through *Amherst* courthouse, and over Long mountain to the Blue Ridge.

The fourth section extends from *Bellfield* on the Meherrin river, through *Brunswick* and *Lunenburg* courthouses to *Charlotte* courthouse. The chief peculiarities presented in this line, are the increasing abundance of the Hornblende Slates and Hornblende Gneiss, the occurrence of Chlorite, associated with numerous bands of Quartz towards its western termination, and the entire disappearace of the belt of primary slates towards the east. This section unites with a previous line of observation extending from *Charlotte* courthouse through *Campbell* courthouse, *New London* and *Liberty*, and terminating in the valley beyond Buford's gap.

The fifth section commences at *Bellfield*, and extends through *Boydton* to *Abbyville* on the Staunton river. The most marked peculiarity observed in this line is the increase of Chloritic and Talcose matter in the rocks observed between *Boydton* and Staunton river, and the occurrence of beds thus impregnated, of a quality admitting of their being wrought as a variety of soapstone.

The sixth section extends from *Weldon* in *North Carolina* through *Ridgway* and *Clarksville* to *Halifax* courthouse. On this line, the greenish Chloritic and Talcose rocks are largely expanded between *Ridgway* and *Clarksville*. The Roanoke exposes in its course extensive and valuable bodies of Seinite and Hornblendic, as well as Felspathic Gneiss, furnishing excellent building materials, which have attracted attention and are worthy of being extensively wrought. This section, terminating at *Halifax* courthouse, unites there with a previous line of observation, extending through *Competition* and *Rocky Mount* in *Pittsylvania* and *Franklin* counties to the Blue Ridge near the Bent mountain.

In the detailed profiles of these and other sections now in progress of construction, the several important bands of rock will be laid down in their proper order and proportion, and with their observed dips, so as, in connection with lateral observations, to convey a more faithful representation of the geological structure of this region than would be practicable by any amount of merely verbal detail.

Proceeding now to a compendious sketch of the outlines of the coal regions lying in *Chesterfield*, *Powhatan*, *Henrico* and *Goochland* counties, we may commence our tracing on the southern bank of the James river, a little west of the United States arsenal. From this point it extends in an irregular line, having a general direction nearly due south to the Chesterfield turnpike, which it crosses about two hundred yards west of Falling creek and near the well known Black Heath pits. Hence continuing nearly in the same direction, and maintaining a course a little east of the road leading from the pits, south to the Genito road, and passing through the western part of St. Leger farm, it crosses Swift creek a short distance below the mouth of Dry creek. Continuing in this direction and a little east of Dry creek for a short distance, it now bends around to a more westwardly course, and striking the creek near its head is prolonged in a line about S. 2° W., which runs east of Winterpock creek, until within about half a mile of the Petersburg and Bevil's bridge road where it crosses it, and maintaining nearly the same course strikes the Appomattox river about one mile above Eppes's falls.

From this point the boundary of the coal rocks coincides with the course of the river as far as Winticomack creek, little or no indications of these rocks being met with on the south side. At the mouth of Winticomack and for a very short distance up the stream a small patch of them is seen, but unassociated with coal. Now abruptly turning to the northwest and following very nearly the course of the river, the boundary line strikes very obliquely across and is marked by primary rocks about one mile below Bevil's bridge, whence it passes to the mouth of Sappony creek and follows the course of the river to near Goode's bridge, presenting one or two small patches of the coal rocks on the south side. From this point, assuming a course nearly due north, it crosses the road from *Colesville* to *Genito*, about half a mile east of Skinquarter creek, and continuing a little east of that creek, crosses the road from *Chesterfield* courthouse to *Genito*, about half a mile from the stream. Thence it is extended so as to intersect Swift creek about one mile below the road from *Genito* to the main *Buckingham* road, and crosses the latter about half a mile east of their junction. From this, it bends more eastwardly, pursuing the Dittoway branch of Jones's creek, and then the creek itself for some distance, it crosses the James river in a line east of northeast, passing on the north side by Dover church and intersecting the broad branch of Tuckahoe creek a short distance above its mouth. Continued thence, it intersects the Three Chopped road a little east of Big Tuckahoe creek and rounds off in the triangle formed by the Manakintown ferry road, the Pounce's Tract road and the Three Chopped road. Now re-crossing the last named road about h[illegible]

mile east of Little Tuckahoe creek and intersecting the Main Tuckahoe near Woodward's pits, it continues to the James river, which it strikes opposite to the point at which the tracing commenced. The length of this area from its most northern to its most southern termination is about thirty miles. Its greatest breadth about eight miles.

In the outline as above sketched, no notice is taken of the small outlying basins on the eastern margin of the field in *Chesterfield* or of the narrow prong of coal measures lying west of Jones's creek on the south side, and west of Sampson's hill on the north side of the river. This prong presenting itself as a very narrow and shallow basin on the north side, extending but a short distance from the river, coalesces with the main basin on Dittoway branch and the upper part of Jones's creek, the ridge of primary rock by which it is cut off gradually flattening down as it extends southwardly. In a similar manner, several other ridges of primary rock entering the basin near its northern margin, divide it into a number of small diverging branches, each of which has its proper boundary, but all, by the flattening of these ridges, coalescing not far from the general outline above laid down. The shape and manner of connection of these branches with the main field, as well as the form and position of the small outlying basins, can only be made apparent by a properly constructed map.

Nearly opposite to the extreme northern part of this coal field, and separated by about three miles of primary rocks, lies the small coal tract, known as the Springfield and Deep Run basin. It is about two miles in length and a quarter of a mile in width, its most southern termination being near Deep Run church, its most northern a short distance south of Chickahominy river.

CHAPTER VII.

OPERATIONS IN THE GREAT WESTERN COAL REGION.

SECTION I.

GENERAL SKETCH OF THE REGION EXPLORED.

In presenting the following brief sketch of our operations during the past season, in the great western coal region, it may be well to remind the reader of the general features of this extensive tract, as described in my report of last year, and to recur to the several groups of strata, which, according to a regular order of superposition, present themselves in successive zones upon its surface. Bearing in mind that this region forms a part of a vast basin of coal-bearing rocks, whose eastern margin entering our state from *Pennsylvania*, passes entirely across it into *Kentucky* and *Tennessee*, it will at once be obvious that the lowest of the series of strata which it includes, however deeply buried by the incumbent rocks towards the centre of the area,

must make their appearance upon its surface throughout a zone of greater or less width lying immediately within the boundary of the basin, and that groups successively higher and higher in the series will be brought to view in zones lying still more towards its interior. The general northwestern dip of the strata on the *Virginia* side of the great basin from the *Pennsylvania* to the *Kentucky* line, and their southwardly dip towards its northern extremity, indicate the direction in which lines of observation should be chosen best suited to develop the various strata comprised in each of the great groups, while they evince the importance of the natural sections formed by the Great and Little Kanawha, the Sandy and other westwardly flowing streams, as well as of the Ohio river throughout its entire course along the western boundary of the state.

Examinations made along these lines, as well as shorter sections, together with extensive longitudinal tracings of particular seams of coal and their accompanying rocks, have shewn that the series of strata by which this vast surface is overspread, observing a regular order of superposition, naturally arrange themselves into four great groups. The first or lowest of these groups, resting on the coarse sandstone or conglomerate of formation XII. described in former reports as constituting the floor upon which the coal measures are outspread, containing several seams of coal, of which generally one, and sometimes two or three are of sufficient extent to be of great economical importance, may be designated as the *Lower coal group*. Occupying the zone next to the margin of the basin, it is sometimes, as on the Kanawha above *Charleston*, expanded over a wide area by broad undulations of the strata, and sometimes, as along the western flank of Laurel Hill, made to disappear at no great distance within the basin by the uninterrupted and somewhat rapid dip of the strata towards the northwest. The rocks comprehended in this group, with the exception of the shales and slates immediately associated with the coal seams, are, for the most part, coarse micaceous sandstones of a grey and light brownish colour, composing thick and massive layers, but little blended with softer shaly strata—with these are associated beds of limestone and the most important seams of iron ore met with in the coal measures.

Next above, we have a series of strata comprising reddish and bluish shales and slates, and grey, bluish and brown micaceous sandstones, destitute of coal, or containing very thin seams of local extent. Beds of limestone, sometimes numerous and important, are also included in this group, and the black flint described in my report of last year as marking the upper boundary of the lower coal series on the Great Kanawha, is found towards its base. This may be called the *Lower shale and sandstone group*.

Still higher in the series, and occupying a zone still more removed from the margin of the basin, we have a group consisting of grey, brownish and greenish micaceous sandstones, reddish and greenish shales, and beds of limestone, in some districts of great thickness, together with several seams of coal, and more especially the great seam which shews itself so extensively in the neighbourhood of Pittsburg.

Wheeling, *Uniontown*, *Morgantown*, *Clarksburg*, Pocotalico creek and other points in our coal region hereafter to be noticed.

To this series of strata we may give the name of the *Upper coal group*. Resting upon this we find an extensive series of rocks consisting of grey micaceous and felspathic sandstones, together with reddish and greenish shales, more or less calcareous, and containing occasionally thin beds of limestone, but entirely destitute of coal. This overspreading the central portions of the basin, comprises the highest strata of our great western coal measures, and may be termed the *Upper shale and sandstone group*.

Directing our observations to the systematic tracing of these several groups, with the view of defining, as nearly as practicable, the zones of surface over which they are spread out, and pursuing, from point to point, the more important seams of coal or strata of limestone, or other valuable materials met with in the respective groups, our operations during the past season, conducted by means of sections and longitudinal tracings were extended over a wide area, portions of which had not been hitherto explored, comprising chiefly the following districts:

First.—The valley of the Great Kanawha, from the falls to *Point Pleasant*, with a portion of the region lying towards the southwest as far as the valley of Big Sandy.

Second.—The valley of the Little Kanawha, from the neighbourhood of *Bulltown* to *Parkersburg*, on the Ohio.

Third.—A large portion of the region lying between the Little Kanawha and the Pennsylvania line, including the valley of the Monongalia as high up as the neighbourhood of *Clarksburg*.

Fourth.—The valley of the Ohio river from the northern extremity of the state to the mouth of Big Sandy at the Kentucky line.

In the northwestern district, as well as the valley of the Ohio and Great Kanawha rivers, our observations, as far as they were extended, were in general carried on with all the minuteness requisite for the economical and scientific purposes of the survey; but in the valley of the Little Kanawha, and the neighbouring regions on both sides, and in the tract lying between the Great Kanawha and Sandy, they were of a cursory or preliminary nature, being designed as a basis for the more thorough exploration of the ensuing season.

Dispensing with a detailed account of the various results of our investigations in these several quarters of the great coal region, I shall confine myself to a brief description of the several strata comprised in the three lower and more important of the groups above defined, in the order in which they occur.

First.—In a section extending from the commencement of the coal measures on the west side of Laurel Hill, in a northwestwardly direction to the lower strata of the upper group; and

Secondly.—In a section along the Ohio river from the northern extremity of *Brooke* county, the most northern point of the state, to the mouth of Big Sandy river at the Kentucky line.

SECTION II.

STRATA COMPRISED IN THE THREE LOWER GROUPS AS DISPLAYED IN A SECTION ACROSS THE MONONGALIA VALLEY.

The following section, exhibiting in detail the various beds of rock and coal seams, included in the three lower groups above described, comprises the results of a continuous series of observations, commencing at the western base of Laurel Hill, following the course of Decker's creek to its mouth, thence pursuing the Monongalia river to the mouth of Scott's run, and continuing up the run to the termination of the section.

As remarked in my report of last year, the anticlinal arrangement of the rocks in Laurel Hill brings to view, towards its top, and in the deep channels of the streams by which it is intersected, rocks subjacent in geological order to the lowest of the coal measures, and appertaining to formations XI. and XII. of the Appalachian series. Along the natural section formed by Decker's creek in its passage through the mountain, the broad arch of these rocks may be distinctly traced, presenting near the centre the sandstones and limestones of XI., and towards the flanks of the ridge, the sandstones and conglomerates of XII.

Omitting for the present, any notice of the former, of which as occurring in this and the parallel axes towards the east, some details were presented in my last report, I will commence the account of the section now proposed to be described with formation XII.

FORMATION XII.

This consists of a coarse silicious sandstone, parts of which are conglomeritic, the pebbles being small and not numerous. It is of a grey and greyish white colour, is compact and not easily broken, and contains some felspathic sand.

This rock forms the superior part of the Laurel Hill axis, and in the line of the present section, is folded entirely over the mountain, disappearing below the bed of the creek on the eastern side, a little above the falls, and on the western a little below Gooseman's bridge. At the falls it is well exposed, dipping towards the southeast, and forming a natural dam, which causes still water in the narrow channel for some distance above, and it is also seen rising in heavy ledges along the flank of the mountain, to a considerable height above the stream. Here, and lower down the creek huge fragments of the rock are crowded together in its channel, obstructing the flow of the stream, and almost concealing it from view. Some of these masses, which have tumbled down from their position in the great arch above, have the dimensions of a small house. At its western exposure, in the neighbourhood of *Gooseman's*, it is scarcely necessary to say that its dip is towards the northwest, and that its western or upper surface marks the commencement of the series of strata already designated as th

lower coal group, to the detailed description of which, and the succeeding groups comprised in the present section, I now proceed.

LOWER COAL GROUP,

OR

FORMATION XIII.

No. 1.

Shale.—Colour yellowish grey and dun, argillaceous, grain generally fine, structure laminated. On exposure to the atmosphere, it disintegrates into clay. Near the bottom of this stratum is an irregular band of iron ore, sometimes forming a continuous layer, but occurring in the form of nodular masses, varying from two to twelve inches in diameter. It is an impure proto-carbonate of iron, covered with layers of hydratic per-oxide, produced by the decomposition of the carbonate. Its colour within, is grey and greyish dun, on the outside yellowish brown. Its grain is coarse, and fracture irregular and sometimes earthy.

This ore is generally of inferior quality, but has been extensively used at the neighbouring furnace. It has been discovered in isolated patches at numerous places on the slope and towards the summit of the mountain, and has been mined at various points along its western base. It disappears below the bed of the creek, between Gooseman's bridge and the furnace, from a third or half mile below the former.

Its average thickness is estimated at 1 foot, that of the shales in which it is contained being about 6 to 10 feet.

No. 2.

Sandstone.—Colour very light grey; grain fine, moderately compact; structure slaty, separating in flags from one to six inches thick. It contains some imperfect specimens of vegetable fossils, mostly of the genus Lepidodendron. It is a very good firestone, and has been used for this purpose at the neighbouring furnace. Thickness about 4 feet.

No. 3.

On the line of section, the strata at this point are concealed, but from disclosures in other places, there is reason to believe that they consist principally, if not entirely, of shales containing some iron ore. Farther examination will be required to determine their true nature and extent; and such examination is rendered particularly important, by the consideration that this unobserved interval occupies a place in the series analogous to that in which some of the valuable beds of iron ore on Cheat river, resorted to by the Henry Clay and other furnaces are embraced.

No. 4.

Sandstone.—Colour greyish white, sometimes with a yellow tinge, due to oxide of iron. Grain coarse and silicious; contains some felspathic sand. Though of a variable character, this rock is usually compact and not easily wrought. It has been used for furnace hearths. It disappears beneath the creek a little below the furnace. In some places, as in the vicinity of Cheat river, this rock so closely resembles formation XII. that the one might readily be mistaken for the other. Thickness from 25 to 30 feet.

No. 5.

Shale.—In part bituminous, imperfectly disclosed. Thought to contain iron ore—yet to be examined. Thickness 15 to 20 feet.

No. 6.

Coal.—In some places this seam consists entirely of the irised or peacock variety. At an opening on the side of Laurel Hill, south of Decker's creek, and about a mile southeast of the furnace, this character is very strikingly displayed. The coal is there quite friable, breaking into small irregular fragments; its quality tolerably good. Thickness 18 inches to 2½ feet.

No. 7.

Flaggy Sandstones and Shales.—The strata are but partially disclosed, but so far as observed, are of the above character. They are supposed to include iron ore. About two miles northeast of the furnace, a seam of ore has been slightly wrought, which is believed to lie among these rocks. This is to be farther explored. Whole thickness about 30 feet.

No. 8.

Coal.—A thin seam, about one foot thick.

No. 9.

Flaggy Sandstones and Shales.—Much concealed by slides, but towards the upper part containing nodules of hydrated per-oxide of iron, to what extent remains to be determined. Thickness about 40 feet.

No. 10.

Limestone.—Colour variable, blue, grey and dun. Some portions yellowish and ferruginous, with small cavities containing yellow ochre. It is a compact rock, of a fine grain and conchoidal fracture. For a few inches near its upper surface, it is yellow, and so highly ferruginous, as in some places to constitute a calcareous iron ore. Occasionally a seam of shale, about a foot thick, is found resting upon this, and above the shale another bed of limestone about a foot thick. This rock sinks below the creek at a point about three fourths of a mile below the furnace. It is likewise met with on Aaron's creek

tributary of Decker's, at a locality which has been examined. It is generally of good quality, and has been found valuable as a source of lime and as a flux; for which latter purpose, it has been used at the furnace. Thickness about 3 to 4 feet.

No. 11.

Shale.—Colour dun and grey, or bluish grey; argillaceous; grain fine; structure lamellar. This stratum contains nodular masses of iron ore, consisting of proto-carbonate of iron within, and concentric layers of hydrated per-oxide on the outside. It is of good quality, but in too small quantity to be of much value. Thickness 8 to 10 feet.

No. 12.

Sandstone.—Colour grey; micaceous; grain fine, rather compact; quarries into flags. Thickness 5 feet.

No. 13.

Shale.—Colour dark blue; argillaceous; grain fine; structure laminated.

The lower part of this stratum includes a layer of nodules of iron ore, varying in size from a small pebble to more than a foot in diameter. It is a rich ore, consisting of the proto-carbonate, coated with hydrated per-oxide, and was the material chiefly used at the furnace. For its composition, the reader is referred to my report of last year, pages 155, 156, Nos. 14 and 15. It was mined on the side of Laurel Hill, in a southeasterly direction from the furnace. The average thickness of the band of ore is from 6 to 10 inches, that of the shales from 6 to 8 feet.

No. 14.

Coal.—Of moderately good quality. Disclosed on Aaron's and Decker's creeks. Thickness 1 to 2 feet.

No. 15.

Shale.—Argillaceous; colour bluish and dun; grain fine; structure laminated; contains a few scattered nodules of iron ore of lenticular form. Thickness 12 feet.

Coal.—Friable, having a tendency to break into small rhombic pieces. Parts of this bed are rendered impure by the presence of sulphuret of iron, but towards the centre it is remarkably free from that mineral, and is hence regarded as of superior value for smith's purposes. It dips below the bed of Decker's creek about one mile below the furnace, and has been wrought at several places in the valley of the creek and on its tributaries. It has also been mined in the bed of the run, about three fourths of a mile north of Gooseman's bridge, and on a stream about the same distance southeast of the furnace, as well as on the main creek at about the same distance below the furnace. It shews itself in the bed of Aaron's creek about two miles from its mouth, and traced in a southwesterly direction,

crosses Booth's, Thom's, White Day, &c. creeks. Thickness 3½ to 4 feet.

No. 16.

Shale.—The lower part of this stratum, resting upon the coal seam above described, (15,) is often black and bituminous, and where disclosed on the run which empties into the creek near the furnace, is very compact, has a conchoidal fracture, and is sometimes irised, bearing a strong resemblance to cannel coal. It is here some 10 or 12 feet thick.

The upper part is argillaceous; colour greyish or dun; structure laminated. This, at the locality above referred to, is about 12 feet thick, but at other places much thicker. Aggregate thickness 30 to 40 feet.

No. 17.

Coal.—A thin seam, which dips below the bed of Decker's creek, a little above the old forge. Thickness about 1 foot. Above this coal is a bed of shale. Thickness 5 to 6 feet.

No. 18.

Sandstone.—Siliceous, containing some Felspathic sand; colour light grey; grain coarse, rather compact, but becoming less so as the bed is traced farther towards the west from Laurel Hill. This rock admits of being quarried in layers of from a few inches to several feet in thickness.

The lower part of this stratum descends to the bed of Decker's creek, near the old forge, but owing to the diminishing steepness of the dip in going towards the west, together with the rapid descent of the creek in the same direction, the upper part of the stratum continues above the bed of the stream to *Morgantown*, where it is exposed in the bed and on the banks of the creek near its mouth in a thickness of from 20 to 30 feet. A little below *Morgantown* it sinks below the bed of the Monongalia river.

Tracing this important stratum along the Monongalia above *Morgantown*, it is seen gradually rising above the bed of the river forming a heavy ledge, partially concealed along the river hills, and at the distance of about one mile above the town its elevation is such as to bring to view the underlying strata as far down as the coal seam No. 15, above described, which is here found in the bed of the river, and was formerly wrought to supply the town before the main seam of the upper coal group was discovered high up in the hills.

On Booth's creek, about one third of a mile from the river, this stratum is seen forming a precipitous ledge some 60 or 70 feet high, known by the name of the "Raven rocks."

Here the rock is less compact than near the mountain, disintegrating by exposure, and, as is common among the sandstones of the coal measures, presenting cavities of various shapes and sizes upon its weathered surface, produced by the removal of the more friab portions of the mass.

This stratum is also disclosed with the same general characters, on Cheat river, White Day creek, Pricket's creek, &c. &c. In some places, it forms a good building material, and has been used in constructing the abutments of the bridge recently built over Decker's creek at *Morgantown*.

This is the highest stratum of the lower coal group, and its upper surface forms the floor upon which the beds of the next superior group repose, to wit: the

LOWER SHALE AND SANDSTONE GROUP,

OR

FORMATION XIV.

This series of beds, included between the lower and upper coal groups, composed principally of shales, but including some beds of sandstone and thin seams of coal, rarely of any workable extent, comprises the following strata:

No. 1.

Shale.—Argillaceous; colour variegated brown and red; grain fine; general structure laminated. Near its lower part, this stratum contains an irregular band of iron ore, from 6 to 8 inches thick. Like the ore No. 5, preceding, it is a proto-carbonate, covered with a coating of hydrated per-oxide. It is of a grey colour, coarse grained, and rough irregular fracture. Where mined near the site of the old forge, it is quite impure, nor is it likely to prove of much value at other points, though in mixture with the ores of better quality, it was used at the furnace. At the forge it is from 40 to 50 feet above the bed of the creek, and continues in view to *Morgantown*, sinking beneath the Monongalia a short distance below the town. Thickness of the shale 10 feet.

No. 2.

Sandstone.—Micaceous; colour grey; grain rather coarse, but variable; structure tending to slaty. This bed varies greatly in thickness at different points, sometimes thinning out or passing into shale. Near the old forge it is twenty feet, at *Morgantown* much less, and at some places assumes the character of merely a shaly sandstone. Thickness twenty feet.

No. 3.

Shales.—Argillaceous; variegated; colour brown, olive, dun and reddish; structure laminated. An irregular seam of iron ore occurs towards the bottom of this stratum, of which some use was made at the furnace. Though concealed by the filling up of the pits, the seam as formerly wrought is known to have an average thickness of about six inches and to be of moderately good quality. It is occasionally calcareous. A few feet above this occurs an irregular course

of nodules of sufficient thickness in some places to have been found valuable. Both this and the other seam, however, are very variable as to quantity, not unfrequently thinning out entirely.

The upper part of this stratum sometimes includes a little bituminous shale, and probably very thin local patches of coal. Thickness about 20 feet.

No. 4.

Limestone.—Colour dark blue or bluish black; grain moderately fine; fracture sometimes conchoidal, sometimes irregular. This stratum furnishes a lime which, according to my experiments, is capable of setting under water with great promptness forming a very hard mass. For the details of its composition see the report of last year, page 151. Localities Rogers' mill and the ravine near *Morgantown.*

No. 5.

Shales.—Argillaceous; variegated; colours brown, dun and reddish; grain generally fine; structure laminated; sometimes containing nodules composed of calcareous and ferruginous matter blended. These shales are in many places partially concealed. Where observed in the ravine at *Morgantown* and the valley of Decker's creek, their thickness varies from about 35 to 50 feet.

No. 6.

Limestone.—This is the position of a thin band of limestone not disclosed in the ravine at *Morgantown* or on Decker's creek, but which occurs on Aaron's creek about a mile from its mouth. It has been used for burning into lime. It is ferruginous, dark coloured and compact, and where seen has a thickness of about 10 inches.

No. 7.

Shale.—Argillaceous; colour grey or dun; structure laminated. Where observed on this section in the ravine at *Morgantown* it is partially concealed, but as well as could be determined its thickness is 10 feet.

No. 8.

Limestone.—Colour yellow; very ferruginous; exfoliates on exposure to the atmosphere; grain moderately fine; fracture earthy. At the place of observation in the section it is quite impure, though it effervesces briskly with acids. Thickness 3 feet.

No. 9.

Shales.—Argillaceous; variegated; colours brown, dun and reddish; structure laminated. This stratum contains some calcareous nodules, imperfectly disclosed in the ravine at *Morgantown*. Estimated thickness 30 feet.

No. 10.

Coal.—This is a thin seam of inferior quality, sometimes passing into bituminous shales. It is exposed on a run about two miles from the mouth of Decker's creek, but was not seen in the ravine at *Morgantown.* Thickness 1 to 1½ feet.

No. 11.

Fossiliferous Shale.—Calcareous; sometimes passing into *limestone;* colour generally greyish and bluish, but sometimes nearly black; containing numerous fossil shells of various genera and species. This stratum may be seen at several places along Decker's creek from the mouth of the ravine at *Morgantown* nearly as high up the stream as the old forge. Estimated thickness about 8 feet.

No. 12.

Sandstone.—Colour dark brown, with a bluish green tint; grain fine; compact, tough; fracture irregular, very difficult to break. Thickness 5 feet.

No. 13.

Shales and Flaggy Sandstones.—Colour of former variegated, brown and reddish; the latter are grey and micaceous. The shales contain some nodules of impure iron ore. These rocks being but imperfectly disclosed, cannot here be fully described. Thickness about 40 feet.

No. 14.

Coal.—This seam and the smaller one, No. 10, appear to attain greater importance along the line of the present section than at any other points in which the intermediate group has been examined. Indeed, in no other places have the strata of that group been found to include any seam of workable extent. The structure of this coal is slaty. It contains some sulphuret of iron, but may be considered of moderately good quality. On Decker's creek it has been wrought at several places as high up as the old forge, where it runs out on the tops of the hills. At one of these openings on the land of *Mr. Wells,* it is about *three feet* thick, and lies at a height of about 170 feet from the bed of the stream. At *Morgantown* its height above the creek is nearly the same, its dip corresponding with the fall of the stream. It sinks below the bed of the Monongalia river, above the mouth of Scott's run, and about two miles below *Morgantown.* Thickness 2½ to 3 feet.

No. 15.

Shale.—Colour grey, sometimes bluish; character varying at different places. Thickness 10 to 15 feet.

No. 16.

Conglomerate.—This curious stratum, composed of a mixture of fragments of limestone, iron ore and Quartzose sand and pebbles, varies greatly at different points, as well in thickness as in composition. In some places the materials are fine, consisting chiefly of iron ore, and the stratum not more than three or four inches thick, in others they are much coarser, containing fragments six or eight inches in diameter, and the stratum is then enlarged to a thickness of four or

five feet. The fragments, though sometimes angular, are in general rounded, and by this and their large size, indicate the continued and violent action of currents, probably of local extent, which preceded and attended their deposition, where they are now found. Thickness from 3 inches to 6 feet.

No. 17.

Sandstone.—Colour yellowish brown, sometimes grey; grain rather coarse. This rock contains some Mica and felspathic sand. It admits of being quarried in blocks from 6 inches to 3 feet thick, is well adapted for some architectural purposes, and has been thus employed at *Morgantown*. On our line of section it runs out, or has its eastern boundary in the hills, a little above the old forge, and continued in a northwestern direction, sinks below the bed of the Monongalia river, at or very near the mouth of Scott's run. Thickness according to estimation at different points, 25 to 35 feet.

The strata included between the sandstone (17,) above described, and the base of the upper coal group, in other words, all the remaining beds of the intermediate group of shales, sandstones, &c., I am now describing, are, to a great extent, concealed at *Morgantown*, as well as in the river hills between that place and the mouth of Scott's run, where, as above mentioned, the last described rock, No. 17, is at or very near the level of the river bed. Quitting Decker's creek and the river, therefore, the section is continued by resuming the enumeration of the rocks at the river level, at the mouth of this run, and describing the strata as they are disclosed in ascending the stream in a northwestwardly direction.

No. 18.

Shale.—Colour brown, or olive brown, grain fine; structure laminated. About three feet of the upper portion contains *calcareous nodules*. Thickness at the place of observation, mouth of Scott's run, estimated at 15 feet.

No. 19.

Limestone.—Ferruginous; weathered surfaces bright yellow; exfoliates on exposure to the atmosphere. In some places the interior portion is of a light drab colour, and a compact fine grain. Thickness 3 to 4 feet.

No. 20.

Shale.—Nearly all concealed, but giving indications that it contains a little coal or bituminous shale. Thickness 10 feet.

No. 21.

Limestone.—The lower part of this bed is of a grey colour, compact, fine grained, and has a conchoidal fracture; the upper part is ferruginous, and exfoliates on exposure to the atmosphere; weathered surface bright yellow; interior compact, and of a bluish colour. Who[le] thickness 3 feet.

Immediately upon this bed of limestone rests a band of *shale.* Thickness 1 foot.

No. 22.

Limestone.—Somewhat ferruginous; weathered surface yellow, but does not exfoliate. In the interior, colour bluish; compact; grain fine; fracture conchoidal. Thickness 3 to 4 feet.

No. 23.

Sandstone.—Colour yellowish brown; grain coarse; compact. Thickness 1 foot.

No. 24.

Sandstone.—Micaceous; colour bluish grey; grain fine; structure laminar; in the lower part including a little shale. Thickness 2½ feet.

No. 25.

Shaly Sandstone.—Colour bluish grey. This bed contains lenticular masses of iron ore, apparently the carbonate, of a bluish tinge, placed with their flattened sides parallel to the lines of lamination, varying from the size of a walnut to masses weighing several pounds. Thickness 4 feet.

No. 26.

Shale.—Colour bluish. The lower part of the bed is argillaceous, of a fine grain, and laminated structure; the upper is somewhat siliceous, of coarser grain, and verging to the character of a shaly sandstone. Thickness 22 feet.

No. 27.

Limestone.—Colour bluish or dun, weathered surface yellow; grain fine; fracture conchoidal. Thickness 1½ feet.

No. 28.

Sandstone.—Micaceous; colour bluish; grain fine; structure laminar. The upper part of the bed is hard and compact; the lower much less so, and sometimes graduating into shaly sandstone. In some cases the lines of lamination are oblique to the plane of stratification, having an inclination towards the northwest. Thickness 10 feet.

Nos. 27 and 28, together with 2 or 3 feet of the upper part of 26, form the falls of Scott's run, at Boyer's, about half a mile above its mouth. 24 and 5 are seen a little below the mill.

No. 29.

Sandstone.—Colour bluish; weathered surface yellowish brown; exfoliates on exposure to the atmosphere. This rock has been used for *whetstones,* and is said to be of some value for this purpose. *Locality,* Boyer's mill. Thickness 5 feet.

No. 30.

Shale.—Colour olive brown; grain rather fine; structure laminated. Locality Boyer's mill. Thickness 4 feet.

Nos. 31 and 32.

Sandstone.—Micaceous; grey, of fine grain, laminar; unchanged by the weather. Thickness 7 inches.

Shale.—Mostly concealed. Thickness 3 feet.

No. 33.

Limestone.—Colour bluish, sometimes tinged with brownish red; weathered surface yellow; grain moderately fine; compact; fracture splintery. Locality near Boyer's mill. Thickness 1½ feet.

No. 34.

Shale.—Mostly concealed, containing some nodules of iron ore. Locality same as above. Thickness 7 feet.

No. 35.

Limestone.—Very impure; colour brown; compact; fracture irregular; slightly micaceous. Locality same as above. Thickness 3 feet.

No. 36.

Shale.—Too much concealed to admit of being accurately described. Estimated thickness 10 feet.

No. 37.

Sandstone.—This stratum presents great and rapid variations of character. It is micaceous, and contains some felspathic sand, and is generally of a light grey colour. In some places, it is compact and sufficiently durable to be used for building; in others, quickly disintegrating on exposure to the atmosphere. (As disclosed on Scott's run it presents a striking illustration of the sudden changes of composition frequently occurring in the strata of the coal measures.) A little below Tribbet's mill, it includes a thin stratum of limestone of sufficient purity to be burnt for lime, but by one of those sudden changes so frequently occurring in the strata of the coal measures, this calcareous band is seen as we descend the stream passing rapidly, though by insensible gradations, into a sandstone (into which in a distance of a few rods it is entirely transformed,) so that in the distance of a few rods the transformation is complete. This sandstone dips beneath the bed of Scott's run a little below Tribbet's mill, and about three fourths of a mile above the mouth of the run. Thickness 25 to 30 feet.

Nos. 38 and 39.

Shale and Coal.—The former is imperfectly disclosed. Thickness 3 feet. The latter is of moderately good quality, and was wrou

for domestic purposes before the discovery of the thick bed some feet above it. Thickness about 2 feet.

No. 40.

Limestone.—Colour bluish black, caused by an admixture of bituminous or carbonaceous matter. Structure rather slaty; grain moderately fine; fracture earthy and irregular. Place of observation one eighth of a mile above Tribbet's mill. Thickness 2 feet.

No. 41.

Shale.—Somewhat micaceous; colour blue and grey; grain generally fine; structure laminar. This bed contains some flattened nodules of proto-carbonate of iron, arranged parallel to the lamination. It sinks below the run about one mile from its mouth. Thickness 14 feet.

The stratum last described forms the highest of the series of beds intervening between the lower and the upper coal group, and thus completes what has been designated as the lower shale and sandstone group.

On a review of this series the amount of calcareous rock included in it, as displayed in the present section, claims attention as one of its most important features. *Eleven bands of limestone* are embraced in this intermediate group in the region now referred to, giving an aggregate thickness of 24 *feet of limestone.* Most of these bands are ferruginous, and otherwise impure, but are yet generally capable of yielding a lime suited to agricultural and building purposes, and even some domestic uses, where the colour is unimportant. Of the eminently *hydraulic* character of one of them, mention has already been made, and I may add that judging by the appearance of the rock of some of the other bands, it is probable that the experiments yet to be made, will shew them to possess similar value in the production of a water cement.

UPPER COAL GROUP,

OR

FORMATION XV.

No. 1.

Coal.—Main Seam of the Upper Group.—Considered in regard to its thickness and the quality of the coal, as well as the extensive area over which it is found, and the facility with which it can be mined and conveyed to market, this is unquestionably the most valuable seam in the coal measures, either in *Virginia* or *Pennsylvania.* By careful tracings conducted in both states, this seam, extensively exposed in the valley of the Monongalia from a point some distance *above Clarksburg* to the state line, has been shewn to be identical with that which is so largely developed in the northern part of the same

valley in its prolongation in *Pennsylvania*, and which is disclosed so extensively in the vicinity of *Pittsburg*. It has been farther proved, that continuing towards the west, this seam, coming to view on the Ohio river, constitutes the main coal stratum displayed in the hills at *Wheeling* and for many miles below; and that still farther down the river, it forms the Pomeroy or Carr's run seam in *Ohio*, and the corresponding bed on the *Virginia* side. While prolonged in a southwesterly direction from the upper part of the Monongalia valley, it crosses the Little Kanawha near Leading creek; displays itself on the Great Kanawha below the mouth of Pocotalico, and on this latter stream, and is continued to the Big Sandy on the Kentucky line.

On the line of the present section, the most eastern outcrop of this seam is about a mile and a half southeastward of *Morgantown*, where it lies at a height of between 400 and 500 feet above the Monongalia river. Dipping very gently towards the northwest, its height at *Morgantown* is about 400 feet, and at the mouth of Scott's run, three miles farther towards the northwest, is reduced to about 170 feet, making an inclination of about 75 feet to the mile. It sinks below the bed of Scott's run about one mile above its mouth, with a dip which there is reason to believe is steeper than from *Morgantown* to that point.

Near *Morgantown*, the thickness of the seam varies from 6½ to 8 feet. Between this place and the mouth of Scott's run, the hills on the east side have not sufficient height to include the coal, but those on the opposite side contain it at *Granville*, where it has been opened, as well as at other points.

As exposed at *Morgantown*, it is overlaid by a thin band of shale, upon which rests a stratum of sandstone about 30 feet in thickness. This rock is coarse, felspathic, and contains a few quartz pebbles. On the east side of the river, it serves as a good index to the position of the coal, but in a northwesterly direction it thins out or changes its character; and on Scott's run there is not a trace of the sandstone remaining.

At *Boyer's* mine, near the mouth of Scott's run, the main coal of this seam attains the great expansion of *nine and a half feet*, and is accompanied by other layers as exhibited in the following measured section, in the ascending order:

1st.	Main coal seam,	9 feet 6 inches.
2d.	Black bituminous shale,	1 foot.
3d.	Coal, tolerably good,	1 foot.
4th.	Bluish shale,	1 foot 8 inches.
5th.	Coal,	3 inches.
6th.	Thin band of bituminous shale.	

No. 2.

Shale.—Argillaceous; partially concealed; grain fine; structure laminar. Parts of this bed are bituminous. Thickness 10 feet.

No. 3.

Limestone.—This is the first of a series of beds of limestone, which, associated with shales, sandstones, and seams of coal, are found extensively developed in this part of the state above the great coal stratum just described, and which, while they furnish a valuable resource to the agriculture and the arts of the region in which they occur, impart naturally an unusual degree of fertility to its soil. Traced towards the southwest, they are seen gradually thinning away as we ascend the valley of the Monongalia. Though of very considerable thickness at *Clarksburg*, and for some distance beyond, they are almost lost on reaching the Little Kanawha river, where their place is occupied by extensive beds of richly productive calcareous shales. On the Great Kanawha they are reduced to a few layers of calcareous nodules included in the shales lying above the Pocotalico seam of coal.

The limestone No. 3, as seen in the present section, has the following characters: Colour, when freshly broken, bluish grey; grain fine; compact; fracture conchoidal. It is subdivided into three principal layers, having an aggregate thickness of 12 feet. Place of observation about a quarter of a mile above the point where the main coal sinks below the bed of the run.

No. 4.

Coal and Shale.—In this interval the strata are very imperfectly revealed. The coal, disclosed at one place only on the section, is of pretty good quality, and has a thickness of from three to four feet.

The rest of the space is occupied by shale with perhaps a little limestone—making together a thickness of about 7 feet.

No. 5.

Limestone—In two layers. Lower layer, colour grey; weathered surface yellow; compact; fracture irregular. This is an impure limestone. Upper layer, colour grey; weathered surface comparatively unchanged; grain fine; fracture conchoidal. This is purer. Aggregate thickness 6 feet 4 inches.

Nos. 6 and 7.

Limestone.—Between this and the preceding bed of limestone, the strata are concealed for about 3 feet. This limestone has the following characters: Colour bluish grey; grain fine; compact; fracture conchoidal. Thickness 3 feet. Aggregate thickness 6 feet.

No. 8.

Limestone.—Colour dark blue, nearly black; grain moderately fine; fracture irregular earthy; structure slaty; thickness about 18 inches. It is included between thin beds of shale, making the aggregate thickness 5 feet 18 inches.

No. 9.

Sandstone.—Micaceous, grey and fine grained. Thickness about 4 feet.

No. 10.

Limestone.—Colour light drab, some parts bluish; grain fine; compact; fracture conchoidal; weathered surface yellow. It occurs in layers of from 4 to 8 inches thickness. Thickness of the stratum 6 to 7 feet.

Nos. 11 and 12.

Coal and Shale.—This seam, second only in importance, as disclosed in the neighbourhood of our section, to the main seam (No. 1,) is here seen resting upon a bed of shale (No. 11,) imperfectly disclosed. The shale is about 5 feet in thickness.

The coal was seen on the line of section only at two localities, to wit: at *Wade's*, nearly two miles above the mouth of Scott's run, and on a branch of that stream on the right in ascending about half a mile from its confluence with the main run. At *Wade's* it displays itself in *a fine seam five and a half feet thick*, at a height of about 10 feet above the bed of the run; and dips below it a little farther up and about two miles distant from the river. At the other locality it is found in the bed of the stream, where it has been slightly wrought for the use of the neighbourhood.

At both mines the coal is of very good quality, containing but little sulphuret of iron.

The eastern outcrop of this bed is somewhere about the mouth of Scott's run, in which vicinity the hills on the western side of the river are of sufficient height to contain this and the other seams of the upper coal group thus far described. Thickness of shale 5 feet; coal 5 feet 6 inches.

No. 13.

Shales.—Argillaceous; colour bluish and grey; grain generally fine; slightly micaceous; structure laminar. In the layers resting immediately above the coal, a few very imperfect impressions of ferns are seen. Place of observation Wade's coal bank. Thickness 20 to 25 feet.

No. 14.

Sandstone.—Micaceous; colour light grey; grain fine; structure laminar. Place of observation same as above. Thickness about 10 feet.

No. 15.

Shales.—Argillaceous; colour brown and blue; grain fine; structure laminar. The lower part contains a few lenticular nodules of moderately good iron ore of the variety usually found in the coal measures; the upper includes imbedded masses of limestone of ir-

regular form from a few inches to more than a foot in diameter, and which at other points may coalesce into a regular stratum. Thickness 12 feet.

No. 16.

Limestone.—Colour grey; grain moderately fine; fracture conchoidal. Approximate thickness 2 feet.

Nos. 17 and 18.

Limestone and Shale.—Immediately above the preceding bed of limestone, we find a stratum of shale but imperfectly disclosed, having a thickness of 2 feet.

The limestone has the following characters: Colour light grey; weathered surface yellow; grain fine; compact; fracture somewhat irregular. Towards the bottom of the stratum, there occurs a layer of about 2 feet thick, containing fragments of another limestone of the same colour. This layer bears the appearance of a Magnesian limestone. The subordinate beds are at this point so imperfectly disclosed as to render a minute description of them at present impracticable. But there is little doubt that the entire thickness of these beds may be safely estimated at 7 to 8 feet.

No. 19.

Shale and Shaly Sandstone.—Shale, colour blue; structure laminar; argillaceous sandstone, colour grey; grain fine; structure laminar; micaceous. Thickness 10 to 12 feet.

No. 20.

Limestone.—Colour variable, grey, blue and drab; grain fine; compact; fracture irregular. This stratum, exposed in a thickness of about 5 feet, appears to be extended along the run but little above its bed, as far as *Jacksonville.* A short distance below the village, this, or a limestone having the same characters, is exposed to a depth of 7 feet, and may be of still greater thickness, extending beneath the bed of the stream. It is here of a light drab colour, and a portion of it (as in No. 18,) contains small fragments of imbedded limestone. Another portion presents the very peculiar aspect of the magnesian limestone, which occurs at *Wheeling* above the main coal seam, and which was found by my experiments last year to furnish a lime possessed of hydraulic properties. [*Vide* report of last year, page 152.] Chemical examinations now in progress will determine this point. Thickness 7 feet.

No. 21.

Shale, Flaggy Sandstone and a little Limestone at bottom. These strata, including a thickness of from 90 to 100 feet, though partly concealed, and therefore incapable of being accurately described at present, display the following general characters:

First.—The strata resting immediately on No. 19 are chiefly shales. They are argillaceous, and of bluish and brown colours, and near the centre include a band of limestone about one foot thick. It is a bluish grey rock, of a fine grain and conchoidal fracture, and acquiring a yellow surface by weathering. Thickness of these strata 40 feet.

Second.—Immediately above the shales we find a stratum of sandstone, grey, micaceous, flaggy, and of moderately fine grain. Thickness abont 15 feet.

Third.—Above this sandstone is a space occupied by soft flaggy sandstones very partially disclosed. Thickness 35 feet.

No. 22.

Limestone.—In layers from 4 to 18 inches thick, presenting marked differences of character.

Lower portion.—Colour very light drab, nearly white; grain fine; fracture conchoidal; contains specks of white calcareous spar. This is a very pure limestone, and having a texture admitting of a good polish, and being variegated by the included spar, would form a pretty marble.

Middle portion.—Colour light brown; grain rather fine; compact; fracture irregular. Of less purity than the preceding.

Upper portion.—Colour bluish, in some places very dark blue, or nearly black; grain moderately fine; compact; fracture irregular. This rock is disposed to break in small rhombic masses, and is inferior in purity to the lower portion. Locality Scott's run, near its head, on the right of the road above *Jacksonville.* Aggregate thickness 5 feet.

No. 23.

Shale with bands of Flaggy Sandstone.—Shale, argillaceous; brown and sometimes blue. Sandstone, grey. Thickness from 20 to 25 feet.

No. 24.

Coal.—This is the highest workable seam met with in the line of our section. Indeed, in no part of the great coal basin, either in our own state or in *Pennsylvania* or *Ohio*, has any large seam yet been discovered, occupying a higher place in the coal measures. Even this, over a large portion of the basin, is comparatively thin and unimportant, and appears to attain its greatest development west of the Monongalia in the neighbourhood of our line of section, and on the Ohio river at some points between Fishing creek and Middle island.

On our present line it runs out on the tops of the hills some two miles below *Jacksonville*, and descending towards the west, shews itself in the bed of Scott's run, between a half and three fourths of a mile above that place. At the place of observation, a mine about half a mile above *Jacksonville*, the following measurements were taken, in the ascending order:

1. Coal; main seam containing a considerable amount of sulphuret of iron, but of pretty good quality, 5 feet.
2. Bituminous shale; black, laminated, 1 foot 4 inches.
3. Coal; tolerably good, 1 foot.
4. Shale; Argillaceous, bluish, 9 inches.
5. Coal; tolerably good, 1 foot 5 inches.
5. Bituminous shale, 8 inches.

The shale, No. 6, forming the uppermost of these layers sometimes expands to a thickness of 15 or 20 feet, and in this case meriting a special description, may be designated by

No. 25.

Shale.—Sometimes bituminous; colours bluish black and bluish; Argillaceous; grain fine; structure laminar. As just stated, this stratum varies in thickness from 8 inches to 20 feet.

No. 26.

Sandstone.—Colour generally grey; grain coarse and siliceous, but contains some felspathic sand. This stratum runs out towards the southeast on the tops of the hills between two and three miles below *Jacksonville.* It is the highest rock of the upper coal group on Scott's run, its upper surface being about on a level with the head of that stream, and it therefore terminates the series of the Decker's creek and Scott's run section. Above this are a few beds of sandstone and shale, together with one or more inconsiderable seams of coal, and perhaps a layer of limestone which should be added to our description to complete the section so as to comprehend the whole of the upper coal group. These, however, are not disclosed along the line of observation which terminates at the dividing ridge between the waters of Scott's run and Dunkard's creek.

From what has already been stated in regard to the mutability of the strata as prolonged from place to place, the above section cannot be looked upon as indicating exactly the thickness and character of the different beds as displayed in a vertical section at any one locality. It will, however, furnish a useful picture of the general features of the different groups of strata which usually preserve some predominant character over a wide area, and will suffice to exemplify the extraordinary mineral wealth through which it immediately passes, as well as of the fertile valley of the Monongalia in general.

The following brief summary of the more important contents of the upper coal group as disclosed along our section will serve to shew the great affluence of this portion of the coal measures as regards those valuable materials, coal and limestone, along the valley of the Monongalia:

Coal in the Upper Coal Group.

			Feet.	Inches.
First or main seam,		No. 1,	9	0
Second seam,		No. 4,	3	6
Third	"	No. 11,	5	6
Fourth	"	No. 24,	7	0
			25	0

Making a total thickness of workable coal in this group along the line of our section and the vicinity of 25 feet.

Limestone in the Upper Coal Group.

		Feet.	Inches.
First or lowest bed,	No. 3,	12	0
Second "	No. 5,	6	4
Third "	No. 7,	3	0
Fourth "	No. 8,	1	6
Fifth "	No. 10,	6	6
Sixth "	No. 16,	2	0
Seventh "	No. 18,	7	6
Eighth "	No. 20,	7	0
Ninth, "	No. 22,	5	0
		50	10

Making a total thickness of limestone in this group, along the line of section, of 50 feet. Adding to these the 5 feet of coal and 24 feet of limestone in the lower shale and sandstone group, and the 9 feet of coal and 3 feet of limestone of the lower coal group, we have *for the whole extent of coal measures embraced in our section, a thickness of about forty feet of coal and seventy feet of limestone*, a result which, making all allowances for fluctuations in particular strata, is well calculated to shew, in a striking point, the ample natural resources of this highly favoured portion of our state.

SECTION III.

STRATA DISPLAYED ON THE OHIO RIVER,

From the mouth of Little Beaver River in Pennsylvania, to the mouth of Big Sandy on the Kentucky line.

The strata disclosed along this line of observation, embrace:

1. The lower coal group, with the exception of those beds which lying near its base, have their outcrop farther towards the north, in *Pennsylvania* and *Ohio*.
2. The lower shale and sandstone group.
3. The upper coal group.
4. The upper shale and sandstone group, excepting those beds which the river hills are not high enough to contain.

At the northern extremity of our section, near the mouth of Little Beaver, the Ohio river flows in the inferior part of the lower coal group, the outcrop of which is farther towards the north. Descending the river from this point to the mouth of Fishing creek, the dip of the rocks is towards the south.

Throughout this distance, the course of the stream deviates but little to the west of south, while the principal diameter or axis of the great coal basin, having a direction more nearly approaching to NE. and SW. is prolonged from its northwestern termination in *Pennsylvania*, in a direction lying to the east of this reach of the Ohio. The river is thus made to approach this central line as it descends towards

Fishing creek, and is there near, but a little west of the axis or centre of the basin. Below this point, assuming a direction more towards the west, it continues to flow nearly parallel with the axis, though a little west, as far as the bend below Mill creek in *Jackson* county. It now by a sudden turn penetrates some distance into the western side of the basin, and the rocks having a dip towards the axis, that is towards the southeast, the strata which, during its previous course, were buried below its bed, are now seen in succession emerging to the surface.

Resuming its southwesterly course at Kerr's run, and preserving that general direction as far as Guyandotte, it continues to expose nearly the same strata appertaining to the western side of the basin throughout the whole distance. Then bending away to the west, it enters the lower coal group about three miles above the mouth of Big Sandy, on the southern boundary of *Virginia*, whence, taking a northwesterly direction, it passes directly across the western side of the basin, and finally, a few miles above *Portsmouth* in *Ohio* passes beyond its margin.

It is obvious, from this sketch of the general directions of the Ohio, in its passage longitudinally through the basin, that it presents a line of observation of great interest, comprising nearly the whole of the strata of the coal measures. Our observations along this line having been chiefly directed to the examination of the three upper groups, are as yet too incomplete to admit of an accurate section, in detail, of the beds appertaining to that portion of the lower group which lies within the limits of the state. I shall, therefore, in the following description, confine myself to a general account of the lower group, as disclosed near the northern extremity of the state, accompanied with the details of one of several approximate sections which have been made in that region, as preliminary to farther more minute investigation—after which I will proceed to the description of a second and third, and a portion of the fourth groups.

SECTION IV.

LOWER COAL GROUP,

As disclosed on the Ohio River, near the Northern extremity of the State.

As already mentioned, the inferior members of this group are not disclosed on the Ohio river at the northern boundary of the state, their outcrop being north of this in *Ohio* and *Pennsylvania*.

The whole group sinks below the bed of the river a little above *Steubenville*, at a point which we have determined and laid down on a profile section of the strata of this region. Occupying the zone nearest the margin of the great coal basin of *Virginia*, *Pennsylvania* and *Ohio*, this group extending from the state of *Ohio* into *Brooke* county *Virginia*, and   county *Pennsylvania*, stretches in a broad curve around the northern end of the basin, embracing the coal and iron region east of *Pittsburg*, and thence continues along the western flank

of Laurel Hill, in a southwesterly direction into *Virginia*, crossing Cheat river near Ice's ferry, Decker's creek a little above *Morgantown*, and the Valley river near the falls. Here the axis of Laurel Hill becomes so flattened near its southern termination, that the group of strata we are describing extends over it unbroken. Continued in a southwesterly direction from this point, it crosses the Little Kanawha near *Bulltown*, the Big Kanawha between *Charleston* and the falls, and the Big Sandy in a space extending some distance above and below the Burning spring.

This group being the great repository of the iron ores found so abundantly in the coal regions of *Ohio* and *Pennsylvania*, at no great distance from the Ohio river, will, on that account, as well as from its valuable beds of coal, demand future minute investigation. At present, as already intimated, I can only indicate the general order of stratification, as exhibited in preliminary sections—and for this purpose, I propose first to present a section taken near the mouth of Little Beaver in *Pennsylvania;* and secondly, two sections taken in the vicinity of *Wellsville*, the one on the *Ohio*, and the other on the *Virginia* side of the river.

Section on the Ohio river, about one mile above the mouth of Little Beaver.

This section, though not taken in *Virginia*, is here introduced as indicating the series of strata which would be found exposed at the northern extremity of *Brooke* county, the various beds at the two places differing in no important particulars.

No. 1. *Sandstone.*—Colour generally grey, grain moderately coarse; quarries into blocks suitable for building purposes. Parts of this rock are so hard and compact, as to be wrought with great difficulty, and have hence been rejected in the construction of the locks on the Sandy and Beaver canal. Estimated thickness 25 feet.

No. 2. *Shales.*—Argillaceous, colour dark blue and black, sometimes bituminous; grain generally fine; structure laminar. This stratum in some places contains courses of nodular iron ore of the variety usually found in the coal measures. At the mouth of Little Beaver, these nodules vary from 3 to 8 inches in diameter. Thickness 30 to 40 feet.

No. 3. *Coal.*—Of tolerably good quality. Thickness from 12 to 22 inches.

No. 4. *Shale.*—Partially concealed. Thickness 4 feet.

No. 5. *Coal.*—Of tolerably good quality. Thickness 2 to 2½ feet.

No. 6. *Shale, with nodules of Iron ore.*—Thickness 15 feet.

No. 7. *Sandy Shale and Shaly Sandstone.*—Colour generally grey. The inferior part of this bed, a little west of the line of section, passes into a coarse grained sandstone, which is probably the general character of this part of the stratum. Estimated thickness 40 feet.

No. 8. *Shale.*—Colour generally bluish, or dun; argillaceous; contains, towards the bottom, nodules of iron ore, though apparently not in large amount. Thickness 36 feet.

No. 9. *Concealed Strata.*—Thickness about 16 feet.

No. 10. *Coal.*—Quality pretty good, but contains some sulphuret of iron. This seam is in general overlaid immediately by the stratum of sandstone to be next mentioned, but in some a thin band of shale is interposed. At the place of section, the coal is about 5 feet thick, but traced under the sandstone a little towards the east, it rapidly diminishes to about 20 inches..

No. 11. *Sandstone.*—Colour rather variable, but generally light grey and brown; grain in some places fine, containing felspathic sand and some mica, the latter producing a slaty cleavage. In other situations, the rock is more massive, and is composed of coarse siliceous sand, with some quartzose pebbles. It is, however, friable, and rapidly disentegrates by exposure to the atmosphere. Thickness estimated at 45 feet.

No. 12. *Shale.*—Argillaceous; structure laminar; contains some nodules of iron ore, and a thin seam of black bituminous shale. Thickness 8 feet.

No. 13. *Sandstone.*—Colour grey or brown; grain moderately fine; structure slaty; the inferior part rather compact. Thickness 10 feet.

No. 14. *Shales.*—Argillaceous; colour dark blue; grain fine; structure laminar. Portions of this heavy stratum are concealed by debris. Thickness 60 feet.

The shale No. 4, of this section, has a character that would seem to adapt it for the manufacture of pottery. At the place of section, it is about 70 feet above the river. Here the subjacent strata are entirely concealed. But at the mouth of Little Beaver, they are disclosed nearly to the bed of the river, and there being no perceptible dip between the two points, the description of these beds in the section was made with reference to the latter place.

Section near Wellsville on the Ohio.

No. 1. *Shaly Sandstone and Sandy Shale.*—Colours greyish and brown. The texture of portions of this bed is admirably adapted for the finer kinds of masonry, and it is made into tombstones of extraordinary beauty. These sandy and shelly rocks, occupying the base of the hills, extend to a height of about 50 feet.

No. 2. *Coal.*—Quality tolerably good. This has been used in burning the hydraulic limestone hereafter to be mentioned. Thickness 1 ft. 10 in.

No. 3. *Shale.*—Partially concealed. Thickness 7 feet.

No. 4. *Sandstone.*—Colour greyish; grain rather coarse; divided into layers from 6 inches to 2 feet thick. Thickness 25 to 30 feet.

No. 5. *Shales.*—Argillaceous. These shales having, in all, a thickness of about 90 feet, include near the middle of their height a band of *hydraulic limestone.* This rock is of a dark bluish or dun colour, moderately fine grain, and generally irregular fracture. It is here about three feet thick, and overlaid by a somewhat thinner band of bluish argillaceous shale. The limestone alone being not sufficiently *hydraulic,* is mingled with an equal quantity of the shale, and the

two are calcined and ground together. On the *Virginia* side this limestone has been traced along the river hills from a point opposite to *Wellsville* up the Ohio to *Liverpool.*

No. 6. *Coal.*—Quality tolerably good. Thickness at various points in the vicinity, 2, 3, and even 5 feet.

North of the locality of the preceding section, in tracing up the Sandy and Beaver canal, near *Frederickton* in *Pennsylvania,* a similar group of limestone, shale and coal to that here described in Nos. 5 and 6 is met with high up in the hills. The limestone and shale are there also united in the manufacture of the cement. It may therefore be inferred that these beds will be found continuously throughout the intervening part of *Virginia.*

No. 7. *Shale.*—Argillaceous; colour brown; grain fine; structure laminar. Thickness about 20 feet.

The coal No. 2, of this section, has been wrought on the *Virginia* side of the river, and dipping with the course of the stream, that is nearly due southwards, sinks beneath it about two miles below the *Wellsville* ferry.

On the farm of *Mr. Hewitt,* on the *Virginia* side, opposite the mouth of Big Yellow creek, a band of limestone and seam of coal occur in the same relative position as the hydraulic layer, and coal Nos. 6 and 7, disclosed at the quarry at *Wellsville,* and which are, no doubt, the continuation of the same strata.

At the mouth of Big Yellow creek, on the opposite side of the river, we meet with the following seams:

The first or lowest occurs from 15 to 20 feet above the water. It is pretty good quality, and has been wrought in several places. Thickness from 2 feet to 2 feet 6 inches.

The second seam lies about 40 feet above the river, imperfectly exposed, a thickness of only 20 inches being shewn.

The third seam at this place is found at the height of 150 to 160 feet above the river. It yields coal of a superior quality, and has been wrought at several points in this vicinity. Thickness between 6 and 7 feet.

This is no doubt the main or middle seam of the lower coal group, and is here so well developed as to assume great economical importance.

All these beds dip gently down the river, but the points at which they severally disappear beneath the water, as well as the local developments of each as extended northward in the river hill, can only be determined by farther investigation.

On the *Virginia* side, on Tomlinson's run, the following strata are presented:

No. 1. *Argillaceous Shale.*—At Freeman's landing, about eight miles above *Steubenville,* this stratum has been extensively used in the manufacture of fire brick, of which 500,000 are said to be made annually, chiefly in the yards of *Mr. Freeman* and the *Messrs. Beale.* At this place the stratum lies at a height of about 50 feet above the river, continued down the stream it disappears below its bed near the mouth of King's creek.

No. 2. *Coal.*—Wrought in several places. Thickness 2½ to 3 feet.

No. 3. *Shale.*—Argillaceous; colour nearly black; laminar. Contains nodules of iron ore of very good quality, but in what amount remains yet to be determined. Thickness 10 feet.

No. 4. *Sandstone.*—Thickness about 30 feet.

No. 5. *Coal.*—Thickness about 3 feet.

No. 6. *Sandstone.*—Thickness about 20 feet.

No. 7. *Shale.*—Argillaceous; grain rather coarse. Thickness 3 feet.

No. 8. *Coal.*—This seam is of good quality and has been wrought. This is probably identical with the third seam of the section at Big Yellow creek above described. It has here a thickness of from 4 to 6 feet.

No. 9. *Shale.*—Of a brown colour. Thickness 5 feet.

No. 10. *Sandstone.*—Grey micaceous and flaggy. Thickness 30 feet.

No. 11. *Shale.*—Yellowish; imperfectly disclosed. Thickness 5 feet.

No. 12. *Shale.*—Colour dun or bluish. This bed contains nodular masses of iron ore varying from 2 to 8 inches in diameter, but though they are present in considerable quantity, farther examination is necessary to ascertain whether they are in sufficient amount to be valuable. Thickness of the shale 10 feet.

No. 13. *Limestone.*—Colour greyish or dun; occurring in the shape of large nodular masses. This rock has been burnt for lime. Thickness 3 feet.

No. 14. *Shale.*—Chiefly concealed. Thickness 10 feet.

No. 15. *Coal.*—Slaty and of inferior quality. Some portions bear a resemblance externally to cannel coal. Thickness 3 to 5 feet.

Above this, to the top of the hill, embracing a thickness of between 80 and 90 feet, the strata are, for the most part, concealed, and no more particular examination was deemed necessary for the general purposes for which the above preliminary section was made. Within this thickness, about 30 feet above the coal last described, there occurs another seam between 2 and 3 feet in thickness, and limestone is seen on the top of the hill.

All the strata of the lower coal group, described in the preceding sections, dipping, as already mentioned, below the bed of the river a little above *Steubenville*, the highest coal seam of this group is seen in the bed of the river about one and a third miles above that place. About a third of a mile farther down than this point, it is wrought by means of a shaft about forty feet deep, and extending about twenty-five feet below the bed of the river. The coal is here of good quality and the seam has a thickness of 3 feet 9 inches. Though not opened on the *Virginia* side, there can be but little doubt of its existing there also.

SECTION V.

LOWER SHALE AND SANDSTONE GROUP,

As disclosed on the Ohio river near the northern extremity of the state.

This group consists as usual principally of shales and sandstones, the former predominating, and often variegated, and contains no workable beds of coal. Having its outcrop on the river hills about eight miles *above Steubenville*, nearly its whole thickness is disclosed in the hill immediately opposite the town. Traced down the river it forms the base of the hills nearly to the mouth of Weegee creek, a short distance above which its southerly dip carries it out of view, beneath the bed of the Ohio. Below this, at the mouth of Pipe creek, by a northwestwardly trend of the river, the superior layers are barely brought to the surface. The river as formerly mentioned flowing in a direction lying westward of the axis of the basin, such an inflexion must carry it *across* the southeasterly dipping rocks of the western side of the basin, and of course bring to light lower and lower strata. In the present case, however, it soon resumes its southerly direction, and the superior layers of the present group brought to light at Pipe creek, again disappear and continue beneath the surface along a part of *Marshall* county and the counties of *Tyler*, *Wood* and *Jackson*, emerge on the western side of the basin about three miles below Kerr's run. Below this point, they do not again sink out of view, but continue to form variable portions of the river hills to the mouth of the Guyandotte. Here, in consequence of the westwardly bend of the river, the inferior members successively rise above the surface, so that near the mouth of Twelve Pole creek, the lowest has emerged and the whole group is above the surface of the river. Towards this extremity of the basin the outcrop of the group. On this, the western side of the basin, the outcrop of the group is on the river, some distance below the state line in *Kentucky* and *Ohio*.

The following sections will illustrate the nature and arrangement of the strata composing this group, as disclosed towards the northern extremity of our line of observation on the Ohio.

Section of the Lower Shale and Sandstone Group in the River Hill opposite Steubenville.

No. 1.

Shaly Sandstone.—Colour greyish; grain moderately fine. This stratum lies in the bed of the ravine at the place of section and about twenty feet above the water of the river. Thickness 10 feet.

No. 2.

Shale and thin seam of Coal.—The former is argillaceous; dark blue or bluish black, and laminar. Thickness 12 feet. The latter is of inferior quality. Thickness 8 inches.

No. 3.

Shale.—Argillaceous; colour dark blue or black; inferior part somewhat stained with oxide of iron. Thickness 18 feet.

No. 4.

Sandstone.—This stratum is of very variable character. In some places it is coarse, massive and felspathic; in others slaty and micaceous. Generally it has a brownish tinge, produced by oxide of iron. Thickness 40 feet.

No. 5.

Shaly Stratum.—Character very variable; predominant colour bluish grey. Some portions are finely laminated argillaceous shale, while others are sandy shale or shaly sandstone, the latter sometimes forming thin bands. Thickness about 90 feet.

No. 6.

Limestone.—Colour generally , but sometimes tinged reddish; subcrystalline; fracture irregular. It is generally impure, containing apparently a large proportion of siliceous matter.

Its most interesting feature consists in its including numerous fragments of Encrini from one sixteenth to two or three inches in length.

No. 7.

Shaly Sandstone.—Colour grey, or bluish grey. Thickness 7 feet.

No. 8.

Shale.—Colour very dark grey; often sandy; sometimes micaceous. Thickness 25 feet.

No. 9.

Sandstone.—Colour generally grey, but in some places brownish, from oxide of iron. Grain siliceous and moderately coarse; occasionally felspathic and micaceous. Thickness about 40 feet.

Above this sandstone, at the place of our section, the strata are mostly concealed, until we reach the upper coal group which here caps the summits of the hills. Within this space, however, shales and sandstones were partially seen at several points, and limestone was met with near the top of the series.

The strata occupying this part of the group being well disclosed near the mouth of Wheeling creek, a little below the city of *Wheeling*, the section may be continued by annexing to the preceding column the results obtained at the latter locality. Though not agreeing in all details with the unfinished portion of the section near *Steubenville*, it will convey a correct impression of its more important features.

Continuation of the preceding section as disclosed near the mouth of Wheeling creek:

No. 10.

Shale, in thin layers interstratified with bands of sandstone. Shale argillaceous, olive coloured, and laminar; sandstone olive coloured. The lower surface of this stratum is about seven feet above the low water mark of the creek. Thickness 10 feet.

No. 11.

Shale, of a reddish or purple colour. Thickness 6 to 8 inches.

No. 12.

Limestone.—Colour grey; grain fine; compact. Thickness 1 foot 6 inches.

No. 13.

Shale.—Colour bluish; indistinctly laminar. The upper portion is argillaceous, containing some impure calcareous nodules; the lower is inclined to be sandy. Thickness 17 feet.

No. 14.

Sandstone.—This rock as quarried on the south side of Wheeling creek, near the city, presents much variety of character. The upper portion at the quarry where these observations were made, has a light drab colour and a fine grain, and contains felspathic sand and scales of Mica. The middle and lower portions consist of the same materials, but in different proportions, and therefore differ from the preceding in texture and colour. Colour yellowish and bluish; structure sometimes finely laminated, the lines of cleavage being formed by the scales of Mica.

Near the base of the stratum, some bands of the rock are calcareous, and are rendered so hard by the cementing power of the carbonate of lime as to be unfit for use. In this calcareous portion are contained vegetable remains in an imperfectly carbonized state, some of them retaining their structure though converted into bituminous coal. The whole stratum, as measured at the quarry, has a thickness of 26 feet.

No. 15.

Shale.—Colour bluish; sandy; passing into slaty sandstone. Thickness 11 feet.

No. 16.

Shale.—Colour yellowish; argillaceous; laminar. This bed contains some nodules of iron ore. Thickness 8 feet.

This forms the highest stratum of the lower shale and sandstone group at *Wheeling*. Continued down the river, it disappears beneath the bed of the Ohio a little above the mouth of Weegee creek.

SECTION VI.

UPPER COAL GROUP ON THE OHIO RIVER.

The inferior members of this group, embracing all the most valuable beds of coal and limestone, dip below the bed of the Ohio river, near the mouth of Sunfish creek. Still lower down the river, the dip becomes more gentle, and so continues to the mouth of Fishing creek. Passing this, the general course of the stream lies a little west of the centre of the basin, along the counties of *Tyler*, *Wood* and *Jackson*. Throughout this distance, there being scarcely any dip in the direction of the river, the inferior members are retained beneath its bed; but farther down the course of the river, changing to the northwest, the whole series rises above the surface near Sliding hill, about three miles below Kerr's run. Below this, they do not again sink below the surface, but form the mass of the strata in the hills as far down as the westwardly bend in the river a few miles above *Guyandotte*. Below this, the whole group soon crops out on the river hills on the western side of the coal basin.

The following section, taken near *Wheeling*, will indicate the nature and order of the strata constituting this group:

No. 1.

Main Coal Seam of the Upper Coal Group, the lowest stratum of this series. The quality of the coal is in general good, the sulphuret of iron contained in it, not being in sufficient amount to injure it for ordinary purposes.

The following measurements, indicating the contents of the stratum, were made on Coal run, the stream uniting with Wheeling creek near the southeast corner of the city:

1. Main coal seam. Thickness 5 feet 3 inches.
2. Argillaceous shale. Thickness 1 foot.
3. Coal of pretty good quality. Thickness 2 feet.

No. 2.

Main Limestone deposit.—This group of calcareous rocks is here more fully developed than at any other point in the coal measures, and forms one of the most interesting features of the economical geology of the region.

The subjoined measurements were also taken on Coal run:

1. Resting immediately upon the coal we have calcareous shale, succeeded by impure limestone. In some localities, the limestone itself is in contact with the coal, the shale being absent. Thickness 11 feet 4 inches.

2. *Limestone.*—Colour very dark brown, inclining to blue; compact. Thickness 9 feet 6 inches.

3. *Calcareous Shale.*—Colour bluish, embracing near the middle a few inches of very inferior bituminous coal, accompanied by a little ituminous shale. Thickness 5 feet.

4. *Limestone.*—Colour very dark bluish black; grain rather coarse; quite impure; exfoliates on exposure to the atmosphere. Thickness 4 feet 2 inches.

5. *Limestone.*—Colour grey; compact; consists of three layers with thin laminæ of argillaceous shale interposed between them. Thickness 6 feet 8 inches.

6. *Calcareous Shale.*—Rather dun coloured. Thickness 1 foot 6 inches.

7. *Limestone.*—Part of this is of a light drab colour; grain moderately fine; fracture earthy. Probably hydraulic, and to be examined with this view. Thickness 17 feet 6 inches.

The entire thickness of this group of limestones (No. 2,) is 53 feet 8 inches.

The remaining part of the present section is derived from observations and measurements made at Wheeling hill, near the National road.

No. 3.

Shale.—Calcareous and bituminous, or carbonaceous; colour very dark grey, inclining to black; rather compact; effervesces briskly with acid; contains some beautiful impressions of fern. Thickness 1 foot.

No. 4.

Coal.—Bituminous, of moderately good quality. Thickness 4 to 6 inches.

No. 5.

Slaty or Shaly Sandstone.—Colour grey. Thickness 8 to 10 feet.

No. 6.

Shale.—Argillaceous; colour bluish; contains some calcareous nodules. Thickness 8 feet.

No. 7.

Shale.—Calcareous; colour yellowish. Thickness 7 feet.

No. 8.

Coal.—Structure slaty, quality not good. Thickness 4 to 6 inches.

No. 9.

Shale.—Argillaceous, and sometimes sandy. Thickness 10 feet.

No. 10.

LIMESTONE.—Colour bluish; composed of marly limestone, with thin bands of compact limestone alternately arranged. Thickness 50 feet.

No. 11.

Shale.—Colour olive green. Thickness 3 feet 6 inches.

No. 12.

Limestone.—Colour light grey; grain moderately fine; rather compact. The upper part sometimes passes into calcareous shale. Thickness 12 to 15 feet.

No. 13.

Shale.—Colour inclining to dun; upper part argillaceous; about one foot near the bottom is calcareous. Thickness 4 feet.

No. 14.

Limestone.—Marly; colour yellowish; lower part contains some compact bands. Thickness 17 feet.

No. 15.

Sandstone.—Sometimes shaly; colour olive; grain rather fine. Thickness 7 feet.

No. 16.

Shale.—Argillaceous and calcareous; effervesces freely with acid. Colour inclining to dun. Thickness 9 to 10 feet.

No. 17.

Limestone.—Colour light grey; compact. Thickness 6 to 8 inches.

No. 18.

Shale.—Calcareous and argillaceous near the top; the lower portion of the stratum indistinctly exposed. Thickness 6 feet.

No. 19.

Limestone.—Colour greyish; impure. Thickness 2 feet 6 inches.

No. 20.

Argillaceous Shale.—Thickness 3 feet.

No. 21.

Shale.—Calcareous; lower portion includes some thin bands of limestone. Thickness 18 feet.

No. 22.

Limestone.—Dove coloured; grain fine; compact; consists of layers from 3 to 18 inches thick, separated by laminæ of argillaceous shale. Thickness 10 feet.

No. 23.

Shale.—Bituminous; colour nearly black. Thickness 1 foot.

No. 24.

Coal.—Of moderately good quality; imperfectly disclosed at place of observation; used as fuel in vicinity; and said to have an average ickness of 2 feet 6 inches.

No. 25.

Limestone.—Of pretty good quality; compact. Thickness 2 feet.

No. 26.

Sandstone.—Colour greyish, and sometimes tinged with oxide of iron; occasionally coarse and felspathic; passing into slaty sandstone and more rarely into sandy shale. By estimation thickness 40 feet.

No. 27.

Shales and Limestone Bands.—Partially concealed. Thickness 40 feet.

No. 28.

Coal.—Opened in the vicinity; but only partially disclosed at the place of observation. Thickness 3 feet.

No. 29.

Shales and Sandstones.—Towards the top the sandstones predominate and are felspathic; but beneath we meet with shales together with thin bands of limestone. These strata extend to the summit of the hill, at the place of observation, viz: on the farm of *Mr. Nichols.* Thickness 80 to 90 feet.

The above series of strata embrace all the beds of the upper coal group. A glance at the details as here given, will be sufficient to indicate the immense economical value of this group in the ample development which it attains on the Ohio in the vicinity of *Wheeling.* Leaving out of consideration the numerous thin bands of limestone associated with some of the strata of shale, the aggregate thickness of limestone here disclosed in the upper coal group is not less than *one hundred and fifty feet.* Of this, much is of a quality suited for the manufacture of lime for architectural purposes, and nearly all is capable of being made available in agriculture. And it may be added that some bands are likely to prove valuable as a source of hydraulic lime.

The great economical importance of the main coal seam as well as the smaller beds above noticed, must be felt by all who are interested in the progress of this enterprising and prospering portion of the state.

The following observations will serve to illustrate the position and character of the main coal seam, No. 1, of the preceding section, as disclosed at various points along the Ohio river. Cropping out on the hills near *Steubenville,* at a height of between three and four hundred feet above low water mark, its southeasterly dip carries it below the bed of the river a little above the mouth of Weegee. Between these points it has been wrought in numerous places on both sides of the river, displaying a thickness varying from four and a half to five and a half feet.

Below the mouth of Weegee, the course of the river being a little east of south, the coal continues to sink still deeper below the bed of the river, as far as the mouth of Grave creek, where it lies at from 60 to 100 feet below the surface. Here, the river turning towards the northwest, and the dip being towards southeast, the coal approaches the surface, and is seen at the mouth of Pipe creek a few feet above low water mark. But below the mouth of Pipe creek, the river resumes its general direction and the coal again sinks beneath the surface. From this point downwards it continues below the bed of the Ohio, at no place probably at a greater depth than 250 feet, to Sliding hill about three miles below Kerr's run. At the base of this hill on the *Virginia* side it has been wrought at low water mark.

Between Sliding hill and Pomeroy's landing, the coal has not been opened on the *Virginia* side on account of the low bottoms which intervene between the hills and the river, but on the opposite side it has been mined in numerous places. In *Ohio* at Kerr's run and Pomeroy's landing, it has been wrought extensively for exportation, more than one million of bushels being annually sent from these mines to *Cincinnati.* Here the average thickness of the seam is something short of five feet.

On the *Virginia* side it has been opened in but few places, though it is easily accessible throughout a distance of from six to eight miles below Pomeroy's landing, after which the hills again recede from the river. As, however, the strata dip towards the southeast, the mines admit less readily of being drained here than on the *Ohio* side.

At Berthesay's bank, about one mile above the mouth of Leading creek, where particular examination was made, the coal was found to lie at a height of about 60 feet above the river at low water, being of pretty good quality, and having a thickness of four feet four inches. Above the coal is a bed of argillaceous shale, from four to five feet thick, containing between the laminæ numerous vegetable impressions, which, however, are too imperfectly preserved to afford good specimens. Surmounting the shale is a heavy sandstone about fifty feet thick, of a greyish colour, and composed of coarse siliceous sand with some scales of Mica, and some felspathic earth. Along this portion of the Ohio the sandstone here referred to is a good index to the position of the coal, and is well marked by the mural escarpment which it frequently forms in the hills above the coal. Ascending the river above Kerr's run, the lower surface of this sandstone sinks to the water level near Sliding hill, but the stratum does not wholly disappear until we proceed upwards a mile or two above Graham's Station. Hence for many miles along the river the coal can be reached by merely sinking through a part or the whole of this sandstone. Including this space, therefore, the *Wheeling* seam is accessible along this part of the Ohio on the *Virginia* side, for a distance of nearly fifteen miles.

On Ten Mile creek, below where the hills recede from the river, the coal has been opened on the land of *Mr. Mitchell,* and is here said to be about six feet thick. Between this creek and *Point Pleasant* are wide bottoms extending back into plains or rather second and third

terraces of unusual width, in the rear of which the hills are low and the strata much concealed. Along this part of the Ohio no thick beds of coal have been opened, although thin seams have been discovered in several places. The same is true of the hills below the mouth of the Kanawha. As the inclination of the strata is such that this coal if continuous must lie in the river hills in this region, it is probable that the seam has greatly diminished in thickness, and is identical with a thin bed which has been opened at numerous localities of which the following are some of the most important.

At *Mr. James Swan's*, near the lower end of Eight Mile island, is a seam about two feet in thickness, overlaid by a heavy bed of coarse sandstone, and lying at an elevation of about 130 feet above the river. A similar seam has also been discovered on the plantation of *Mr. Charles Lewis*, on Oldtown creek.

In the hill three fourths of a mile NE. of *Point Pleasant* is a seam of good coal, 2½ feet thick, lying at an elevation of about 18 feet above high water mark (of 1832.)

A coal seam of from 2½ to 3 feet thick has been partially wrought at several places between *Point Pleasant* and *Gallipolis*, on the *Virginia* as well as the *Ohio* side.

On the land of *Gen. Steinbergen*, one and a fourth miles from the Ohio a seam has been opened having a thickness of between two and three feet. It is overlaid by a thin band of shale upon which rests a heavy coarse grained sandstone of a greyish colour, closely resembling that resting above the coal at Kerr's run. The coal lies at a height of about twenty-two feet above high water mark.

Below *Steinbergen's* the course of the river is a little east of south for about twelve miles to the bend in the river below Eighteen Mile creek. In this distance, however, the dip of the rocks is very slight, and the coal may generally be readily traced in the river hills. This is also the case with the superincumbent sandstone, though somewhat variable in character and thickness. The coal has been disclosed by *Mr. Menager* between one and two miles below Crab creek. It is here separated near the centre by a band of shale, giving the following section:

1.	Coal, of good quality,	1 foot 10 inches.
2.	Shale, - -	1 foot.
3.	Coal, - -	1 foot 3 inches.

Descending the river, the coal continues to increase in thickness so that about three miles or a little more below *Menager's* it is about four feet thick, and has been opened on the *Ohio* side of the river at various places, on a level but little above the high water mark of 1832. On the *Virginia* side, the hills recede from the river, leaving wide intervening bottoms—and hence the seam has here not been explored.

Below Eighteen Mile creek the strata again rise in the hills, and though in some places pretty well disclosed, present no coal seam of important thickness. Thin bands, varying from eighteen inches to two feet, are found in the hills from Green bottom to *Guyandotte*—but under such variable circumstances as to render their identification at *distant points* impossible.

In the river hill, four miles above *Guyandotte*, is a thin coal seam, which, as exposed thence to *Guyandotte*, appears to occupy the same geological position as the Pomeroy bed, and is, like that, overlaid by a coarse heavy sandstone.

Passing the mouth of Guyandotte river, the strata of the upper coal group soon crop out on the summits of the river hills, and as before mentioned, are succeeded, as we descend the river, by the lower shale and sandstone group, and then by the lower coal group, from the base of which the river emerges in the neighbourhood of *Portsmouth* in *Ohio*.

CHAPTER VIII.

CHEMICAL DETAILS.

SECTION I.

LIMESTONES FROM THE PRIMARY.

1. Limestone from Whitley's quarry, burned for lime. Colour bluish grey; appearance vitrious; structure compact fine grained; fracture irregular; traversed by thin veins of Calc spar.

Carbonate of lime, - -	75.56
Carbonate of magnesia, - -	12.44
Alumina and oxide of iron, -	0.40
Silica, - - - -	11.20
Water, - - - -	0.40

2. Limestone from Gibson's vein. Colour deep pink, with spots of grey white; structure compact; crystalline; surface rough.

Carbonate of lime, - -	77.48
Carbonate of magnesia, - -	5.20
Alumina and oxide of iron, -	1.20
Water, - - - -	0.40
Silica, - - - -	15.72

3. Limestone from Gibson's quarry, south side of Rapidan river. Colour greyish blue, traversed by white veins; structure compact; semi-crystalline; vitreous appearance; fracture Irregular, rough.

Carbonate of lime, - -	90.40
Carbonate of magnesia, - -	6.44
Alumina and oxide of iron, -	0.52
Silica, - - - -	2.00
Water, - - - -	0.64

4. Limestone from *Colby Coward's*, 1½ miles from *Gordonsville*. Colour deep blue; surface of cleavage shining; structure slaty; fine grained; crystalline in places.

Carbonate of lime, - -	79.20
Carbonate of magnesia, trace.	
Alumina and oxide of iron, -	0.80

Silica, - - - -	19.60
Water, - - - -	0.40

5. Limestone from Rawlings' quarry, ½ mile SE. of meeting house, near Orange courthouse. Colour dark blue; structure slaty; crystalline in veins; fine grained compact; surface shining.

Carbonate of lime, - -	73.68
Carbonate of magnesia, - -	9.28
Alumina and oxide of iron, -	0.80
Silica, - - -	15.60
Water, - - -	0.64

6. Limestone from Rapidan river, 300 yards east of Gibson's vein; colour deep blue; aspect vitrious; structure compact; surface scaly; angles acute.

Carbonate of lime, - -	75.44
Carbonate of magnesia, - -	5.04
Alumina and oxide of iron, -	0.92
Silica, - - -	17.92
Water, - - -	0.68

7. Limestone from Todd's quarry, 5 miles from Gordonsville, near blacksmith shop. Colour beautiful pink, traversed by minute white veins; structure compact, granular; semi-crystalline; fracture irregular, sharp angled.

Carbonate of lime, - -	51.72
Carbonate of magnesia, - -	42.72
Alumina and oxide of iron, -	1.28
Silica, - - -	3.28
Water, - - - -	1.00

8. Limestone in thin layers in mica slate. Colour pink, rib-banded; veined with dark crystalline spar; structure granular.

Carbonate of lime, - -	80.72
Carbonate of magnesia, - -	7.12
Alumina and oxide of iron, -	0.44
Silica, - - - -	11.04
Water, - - - -	0.68

SECTION II.

LIMESTONES OF FORMATION II.

1. Limestone from near *Winchester*, on the turnpike west of the town. Colour bluish grey, spotted and streaked with dull grey; structure hard and compact; fracture conchoidal; surface smooth.

Carbonate of lime, - -	80.60
Carbonate of magnesia, - -	14.48
Alumina and oxide of iron, -	1.68
Silica, - - -	2.68
Water, - - -	0.56

2. Limestone from Dunlap's creek, near Sweet springs, *Monroe* county. Colour bluish grey; traversed by minute veins of white spar, structure compact; surface rough and irregular.

Carbonate of lime, - -	86.52
Carbonate of magnesia, - -	9.52
Alumina and oxide of iron, -	0.52
Silica, - - -	2.96
Water, - - -	0.48

3. Lime from *Page* county. Colour blue, with a dull ash lustre; structure compact; fine grained; fracture irregular, with smooth surfaces, acute angled.

Carbonate of lime, - -	70.16
Carbonate of magnesia, - -	25.96
Alumina and oxide of iron, -	1.60
Silica, - - -	1.48
Water, - - -	0.80

4. Limestone from near Harper's Ferry. Colour delicate flesh; aspect semi-crystalline, structure slaty, compact, fine grained, surface irregular.

Carbonate of lime, - -	81.16
Carbonate of magnesia, - -	10.80
Alumina and oxide of iron, -	0.52
Silica, - - - -	6.68
Water, - - - -	0.84

5. Limestone from Stage road, *Shenandoah* county. Colour bluish grey, aspect vitrious, compact, surface rather rough, angles sharp, splintery.

Carbonate of lime, - -	49.00
Carbonate of magnesia, - -	38.80
Alumina and oxide of iron, -	0.84
Silica, - - -	10.80
Water, - - -	0.56

6. Limestone from Shenandoah river, *Page* county. Colour lead grey, spotted with white; structure crystalline; fracture irregular, with rough surface; compact.

Carbonate of lime, - -	47.48
Carbonate of magnesia, - -	45.80
Alumina and oxide of iron, -	0.80
Silica, - - - -	5.40
Water, - - - -	0.56

7. Calcareous sandstone from the Woodstock road leading into Big Fort valley. Colour dark bluish grey, with a light yellow tinge, veined with spar; compact, irregular fracture, with minute scales of mica.

Carbonate of lime, - -	11.24
Carbonate of magnesia, - -	5.40
Alumina and oxide of iron, -	9.36
Silica, - - - -	73.20
Water, - - - -	0.80

8. Limestone from *Page* county. Colour bluish grey; structure compact; very fine grained; fracture irregular, scaly.

Carbonate of lime, - -	60.92
Carbonate of magnesia, - -	36.48
Alumina and oxide of iron, -	0.60

Silica,	- - - -	1.44
Water,	- - - -	0.56

9. Limestone from New Market, *Shenandoah* county, near the junction of II. and III. Colour greyish blue, traversed by veins of dark crystalline spar; structure compact; fine grained; fracture irregular; surface waving.

Carbonate of lime,	- -	81.00
Carbonate of magnesia,	- -	10.60
Alumina and oxide of iron,	-	0.28
Silica,	- - - -	7.60
Water,	- - - -	0.52

10. Limestone from two miles southwest of Harper's Ferry. Colour light grey, clouded with blue, dull pale streak; structure very compact, granular, semi-crystalline; fracture irregular, conchoidal.

Carbonate of lime,	- -	53.88
Carbonate of magnesia,	- -	43.40
Alumina and oxide of iron,	-	0.48
Silica,	- - - -	1.68
Water,	- - - -	0.56

11. Limestone from Northwest turnpike, west from *Winchester*. Colour dirty pale grey, clouded with blue; structure compact, granular, somewhat crystalline; fracture irregular, rough, angular.

Carbonate of lime,	- -	88.64
Carbonate of magnesia,	- -	9.60
Alumina and oxide of iron,	-	0.12
Silica,	- - - -	1.30
Water,	- - - -	0.44

12. Limestone from Chesnut ridge, north fork of Holston river. Colour light grey, with a dull lustre; structure compact; semi-crystalline; fracture irregular, angular.

Carbonate of lime,	- -	50.96
Carbonate of magnesia,	- -	39.20
Alumina and oxide of iron,	-	0.80
Silica,	- - - -	8.48
Water,	- - - -	0.56

13. Limestone from east base of North mountain, Price's road. Colour rather dark grey, slightly tinged brown; surface scaly, compact; aspect vitrious.

Carbonate of lime,	- -	52.20
Carbonate of magnesia,	- -	38.40
Alumina and oxide of iron,	-	1.16
Silica,	- - -	7.44
Water,	- - -	0.80

14. Limestone from *Page* county. Colour blue, traversed by thin veins of spar; appearance vitrious; structure compact; fracture conchoidal.

Carbonate of lime,	- -	69.60
Carbonate of magnesia,	- -	27.04
Alumina and oxide of iron,	-	0.40
Silica,	- - - -	2.60
Water,	- - - -	0.36

15. Limestone from Northwest turnpike, 1 mile west of *Winchester*. Colour grey blue; aspect vitrious; structure compact; semi-granular; surface scaly; fracture smooth, corners sharp.

Carbonate of lime, - -	57.24
Carbonate of magnesia, - -	28.80
Alumina and oxide of iron, -	1.56
Silica, - - - -	11.68
Water, - - - -	0.72

16. Limestone from Stage road, *Shenandoah* county. Colour dark blue; contains crystalline spar; structure compact; fine grained; fracture irregular.

Carbonate of lime, - -	75.96
Carbonate of magnesia, - -	9.12
Alumina and oxide of iron, -	0.92
Silica, - - - -	13.60
Water, - - - -	0.40

SECTION III.

LIMESTONES OF FORMATION XI.

1. Limestone from Muddy creek mountain, *Greenbrier* county. Colour pale lead, tinged with brown; spotted with ferruginous matter; oolitic; structure compact, semi-crystalline; fracture conchoidal.

Carbonate of lime, - -	88.64
Carbonate of magnesia, - -	9.60
Alumina and oxide of iron, -	0.12
Silica, - - -	1.20
Water, - - -	0.44

2. Limestone from gap of Little North mountain, between Crimson sulphur spring and Union. Colour grey blue, tinged with brown; partially crystalline; structure compact; fracture irregular.

Carbonate of lime, - -	78.48
Carbonate of magnesia, - -	9.20
Alumina and oxide of iron, -	1.00
Silica, - - -	10.80
Water, - - -	0.52

SECTION IV.

LIMESTONES OF THE COAL MEASURES.

1. Limestone from Ten Mile creek, *Kanawha*, one mile from its mouth; bed from eighteen to twenty-four inches in thickness. Colour pale lead, with a brown tinge; structure moderately compact; fine grained; fracture splintery.

Carbonate of lime, - -	86.80
Carbonate of magnesia, trace.	
Alumina and oxide of iron, -	1.92
Silica, - - - -	10.88
Water, - - - -	0.60

2. Limestone from Two Mile creek, *Kanawha*, lower stratum one to two feet in thickness. Colour lead brown, with a yellow tinge; structure compact; fine grained; fracture scaly.

Carbonate of lime,	- -	83.92
Carbonate of magnesia,	- -	2.80
Alumina and oxide of iron,	-	0.80
Silica,	- - - -	1.76
Water,	- - - -	0.72

3. Limestone from Coal river at lowest falls, *Kanawha*. Colour dull brown, with a yellow tinge, spotted with Calc spar; structure compact; fine grained; fracture irregularly conchoidal.

Carbonate of lime,	- -	83.96
Carbonate of magnesia,	- -	13.20
Alumina and oxide of iron,	-	0.48
Silica,	- - - -	1.68
Water,	- - - -	0.68

4. Limestone from Ten Mile creek, one mile from its mouth. Colour pale lead, tinged with yellow; structure compact; fine grained; fracture irregular.

Carbonate of lime,	- -	84.40
Carbonate of magnesia, trace.		
Alumina and oxide of iron,	-	1.68
Silica,	- - - -	13.28
Water,	- - - -	0.64

5. Limestone from Little Buffaloe, *Kanawha*, bed 18 inches in thickness. Colour pale yellowish red; structure compact; fine grained; surface smooth; fracture conchoidal.

Carbonate of lime,	- -	72.52
Carbonate of magnesia,	- -	6.80
Alumina and oxide of iron,	-	1.40
Silica,	- - - -	18.72
Water,	- - - -	0.56

6. Limestone from Eighteen Mile creek, *Kanawha*, three miles from its mouth at the saw mill. Colour pale lead, tinged with yellow; fine grained; compact; fracture irregular; corners sharp.

Carbonate of lime,	- -	55.96
Carbonate of magnesia,	- -	7.60
Alumina and oxide of iron,	-	3.68
Silica,	- - - -	31.92
Water,	- - - -	0.84

7. Limestone from Two Mile creek, *Kanawha*, upper stratum, bed from 1 foot to 2 feet thick. Colour light yellow, with spots of dark coloured Calc spar; very fine grained; compact; surface waving.

Carbonate of lime,	- -	96.20
Carbonate of magnesia, trace.		
Alumina and oxide of iron,	-	1.60
Silica,	- - - -	1.60
Water,	- - - -	0.60

8. Limestone from Tyler's creek, *Kanawha*, bed 1 foot thick. Colour yellowish light brown; compact; fine grained; fracture irregular; corners sharp.

Carbonate of lime, - -	75.80
Carbonate of magnesia, trace.	
Alumina and oxide of iron, -	5.20
Silica, - - - -	17.00
Water, - - - -	2.00

9. Limestone from Big Buffaloe, *Kanawha*, bed 2 feet thick. Colour fresh; fracture lead; aspect earthy; compact; rather fine grained.

Carbonate of lime, - -	73.44
Carbonate of magnesia, - -	5.32
Alumina and oxide of iron, -	2.16
Silica, - - - -	18.48
Water, - - - -	0.60

10. Limestone from Crooked creek, *Point Pleasant*, *Mason* county. Surface variegated; curiously spotted with beautiful dark coloured spar; finely crystallized; compact.

Carbonate of lime, - -	79.84
Carbonate of magnesia, - -	6.28
Alumina and oxide of iron, -	3.52
Silica, - - - -	9.68
Water, - - - -	0.68

11. Limestone from Two Mile creek, *Kanawha* county, upper stratum one foot in thickness. Colour grey brown, with a tinge of yellow, spotted with white spar; compact; fine grained; surface waving.

Carbonate of lime, - -	89.72
Carbonate of magnesia, trace.	
Alumina and oxide of iron, -	2.00
Silica, - - - -	7.20
Water, - - - -	1.08

It should be remarked that most of the limestones of the coal measures exhibit traces of carbonaceous matter, which, however, is burned off in the kiln, while those which contain a considerable amount of oxide or carbonate of iron make a dark lime. In many cases they yield a lime which is *hydraulic*, as in the instances mentioned in my last report, as well as in others, now in course of observation.

SECTION V.

COALS FROM FORMATION XIII.

1. Coal from *Judge Summers'* bank, Coal creek, *Kanawha*. Somewhat compact, cleaves into thin laminæ, striated, cleavage surface has a charred appearance; fresh fracture, shining jet black.

Carbon, - - -	55.55
Volatile matter, - - -	41.85
Ash, - - -	2.60

2. Coal from *Judgs Summers'* vein, Grand creek, *Kanawha.* Compact, fracture irregular, surface smooth, jet black and irridescent, striæ indistinct.

Carbon,	-	-	-	52.75
Volatile matter,	-	-	-	43.20
Ash,	-	-	-	4.05

3. Coal from Wolf creek, ½ mile above the Burning spring, Big Sandy. Laminated, surface brilliant shining jet black, easily fractured, and when broken, exhibiting an irregular pitted surface, striæ indistinct.

Carbon,	-	-	-	47.15
Volatile matter,	-	-	-	48.00
Ash,	-	-	-	4.85

4. Coal found in the bed of Big Coal river, 5 miles above the junction of the two branches, *Mr. Jno. Lewis.* Cleaves into laminæ, the surface of which is covered with films of charcoal, cross fracture jet black shining, irregular; striæ distinct.

Carbon,	-	-	-	50.20
Volatile matter,	-	-	-	47.10
Ash,	-	-	-	2.70

5. Coal from *Mr. Cartrell's* property, Three Mile creek, *Kanawha* county. Semi-compact, somewhat laminated; fracture irregular; surface dull black, with spots of shining jet black.

Carbon,	-	-	-	45.95
Volatile matter,	-	-	-	50.30
Ash,	-	-	-	3.75

6. Coal from *Friend, Welsh & Co.'s* mines, Elk river, *Kanawha* county. Massive, fracture irregular, lustre dull black, sometimes shining jet black; striæ distinct.

Carbon,	-	-	-	55.90
Volatile matter,	-	-	-	39.90
Ash,	-	-	-	5.20

7. Coal from *Mr. Lawson's* opening, Logan courthouse, 3 feet thick. Massive, cross fracture shining jet black, striæ indistinct.

Carbon,	-	-	-	58.35
Volatile matter,	-	-	-	39.50
Ash,	-	-	-	2.15

8. Coal from Traa fork, Guyandotte, 5 feet thick. Massive, tentency to columnar structure, dull black irregular fracture.

Carbon,	-	-	-	56.50
Volatile matter,	-	-	-	42.00
Ash,	-	-	-	1.50

9. Coal from Pigeon creek, Big Sandy river. Shining jet black, surface of lamina charred, fracture irregular.

Carbon,	-	-	-	55.00
Volatile,	-	-	-	41.00
Ash,	-	-	-	4.00

SECTION VI.

IRON ORES FROM THE PRIMARY.

1. Iron ore from Ross furnace, Hopewell creek, hematitic brown oxide. Structure somewhat fibrous and cellular, interior of cells coated with a bluish crust; colour clove brown, lustre glimmering and resinous.

Composition in 100 parts.

Per-oxide of iron, - -	81.11
Alumina, - - -	0.28
Silica and insoluble matter, -	6.54
Water, - - -	11.10
Loss, - - -	0.97

Per cent metallic iron, 56.77

2. Iron ore, from Yeatman's, Stonewall creek, composed of brown hematite and silicious brown oxide. Structure externally hematitic, fibrous; internally amorphous, granular; colour blackish brown, lustre glimmering.

Composition in 100 parts.

Per oxide of iron, - -	76.00
Alumina, - - -	0.50
Silica and insoluble matter, -	13.00
Water, - - -	10.00
Loss, - - -	0.50

Per cent metallic iron, 53.20

3. Iron ore from Elk creek, half a mile above mouth.

Structure amorphous, cellular; colour chesnut brown; general aspect earthy, in spots glimmering.

Composition in 100 parts.

Per-oxide of iron - - -	84.00
Alumina, - - - -	0.85
Lime, mere trace.	
Silica and insoluble matter, -	7.60
Water, - - - -	7.10
Loss, - - - -	0.45

Per cent. met. iron, 58.80.

4. Iron ore from *Colonel Hancock's* farm, east side of Falling river.

Structure amorphous; compact; fine grained; fracture somewhat conchoidal; colour chesnut brown, without lustre.

Composition in 100 parts.

Per-oxide of iron, - - -	84.20
Alumina, - - - -	0.56
Lime, trace.	
Silica and insoluble matter, -	4.50
Water, - - - -	10.00
Loss, - - - -	0.74

Per cent. met. iron, 58.94.

5. Iron ore associated with Talcose slate, from bank six miles southwest of *New Canton.*

Structure massive, compact and silicious; colour clove brown; face presenting glimmering points of quartzose particles.

Composition in 100 parts.

Per-oxide of iron, - - -	64.95
Alumina, - - - -	2.65
Oxide of manganese, a trace.	
Silica and insoluble matter, -	23.30
Water, - - - -	10.00
Loss, - - - -	0.20

Per cent. met. iron, 45.49.

6. Iron ore from same locality as above.

Structure cellular; cells minute; colour light brown ochreous; tains small specks of Quartz.

Composition in 100 parts.

Per-oxide of iron, - - -	72.00
Alumina, - - - -	1.33
Silica and insoluble matter, -	16.47
Oxide of manganese, a trace.	
Water, - - - -	10.04

Per cent. met. iron, 50.40.

SECTION VII.

IRON ORES FROM FORMATION I.

1. Honeycomb ore, Graham's bank, Reed creek, *Wythe* county

Structure somewhat cellular; walls of cells compact and c grained; aspect of surface earthy, of interior slightly resinous; co chesnut brown.

Composition in 100 parts.

Per-oxide of iron, - - -	79.49
Alumina, - - - -	0.75
Silica and insoluble matter, -	8.46
Water, - - - -	11.00
Loss, - - - -	0.30

Per cent. met. iron, 54.94.

2. Iron ore from Furrey's bank, *Page* county.

Structure cellular and hematitic, filled with reddish oxide, very nacious and rough.

Composition in 100 parts.

Per-oxide of iron, - - -	79.74
Alumina, - - - -	0.75
Silica, - - - -	7.67
Water, - - - -	11.58
Loss, - - - -	0.26

Per cent. met. iron, 55.81.

3. Furrey's bank, *Page* county.

Structure hematitic, in slender slatactitic columns; colour bl black; spans between the columns occupied by a rich orange oxide; lustre resinous and irridescent.

Composition in 100 parts.

Per-oxide of iron, - - -	74.56
Alumina, - - - -	4.50
Lime, trace.	
Silica and insoluble matter, -	5.80
Water, - - - -	15.00
Loss, - - - -	0.14

Per cent. met. iron, 52.19.

4. From shales of FI, *Augusta* county.

Structure somewhat crystalline; hematitic, compact; colour dark chesnut brown.

Composition in 100 parts.

Per-oxide of iron, - - -	85.87
Alumina, trace.	
Silica and insoluble matter, - -	2.50
Water, - - - -	10.90
Loss, - - - -	0.73

Per cent. met. iron, 60.10.

5. Iron ore from Poplar Camp furnace, *Wythe* county.

Structure irregular nodular; close grained, somewhat cellular; colour dull brown, without lustre, earthy.

Composition in 100 parts.

Per-oxide of iron, - - -	72.04
Alumina, - - - -	1.55
Silica and insoluble matter, -	4.45
Water, - - - -	11.35
Loss, - - - -	0.61

Per cent. met. iron, 50.42.

SECTION VIII.

IRON ORES FROM FORMATION II.

1. Iron ore from Cedar creek works, 2 miles from *Russell* court-house.

Structure hematitic, cellular; brown black, interior of cells lined with a dull brown oxide.

Composition in 100 parts.

Per-oxide of iron, - - -	72.65
Alumina, - - - -	3.75
Per-oxide manganese, trace.	
Silica and insoluble matter, -	11.50
Water, - - - -	12.00
Loss, - - - -	0.10

2. From near *Miller's*, now *Kanage's* iron furnace, Mossy creek, *Augusta* county. Structure cellular, cells ochreous, compact, fine grained semi-crystalline; colour chesnut brown, bright.

Composition in 100 parts.

Per oxide of iron, - -	81.00
Alumina, trace.	

Silica and insoluble matter, -	9.50
Water, - - -	9.27
Loss, - - -	0.23

Per cent. metallic iron, 56.70.

3. Iron ore, from Silver creek, used at *Kanage's* furnace. Structure compact, fine grained, surface smooth; colour dark reddish brown.

Composition in 100 parts.

Per-oxide of iron, - -	82.00
Alumina, trace.	
Silica and insoluble matter, -	8.14
Water, - - -	9.27
Loss, - - -	0.59

Per cent. metallic iron, 57.40.

4. Iron ore from *Wythe* county, base of Iron mountain. Structure cellular; colour dark dull chesnut brown, semi-crystalline.

Composition in 100 parts.

Per-oxide of iron, - -	92.00
Alumina, trace.	
Silica and insoluble matter, -	4.00
Water, - - - -	3.29
Loss, - - - -	0.71

Per cent. metallic iron, 64.40.

SECTION IX.

IRON ORES FROM FORMATION V.

1. Iron ore from Poor Valley ridge, near Cumberland gap. Structure slaty, laminated, fossiliferous. Colour rich brown, with a semi-metallic lustre, arising from the micaceous character of the fossil casts which cover the surface.

Composition in 100 parts.

Per-oxide of iron, - -	76.50
Alumina, - - -	7.60
Ox. manganese, trace.	
Carbonate lime, - - -	1.00
Magnesia, trace.	
Water, - - - -	3.00
Silica and insoluble matter, -	11.30
Loss, - - - -	0.60

Per cent. met. iron, 53.55.

2. From the Blooming, south of road on western side Capon mountain. Structure cellular, cells lined with hematite; colour dark chesnut brown.

Composition in 100 parts.

Per-oxide of iron, - -	84.80
Alumina, trace.	
Silica and insoluble matter, -	3.50
Water, - - - -	11.12
Loss, - - - -	0.58

Per cent. met. iron, 59.36.

SECTION X.

IRON ORES FROM THE WESTERN COAL MEASURES.

1. Iron ore from Keller's creek, interspersed in shales, *Kanawha.* Nodular iron ore; structure nodular, compact, close grained; colour of the mass dull reddish grey, of crust reddish brown; fracture somewhat conchoidal.

Composition in 100 parts.

Carbonate of iron, - -	82.55
Alumina, - - - -	1.00
Lime, trace.	
Silica and insoluble matter, -	12.05
Water, - - - -	3.50
Loss, - - - -	0.90

Per cent. met. iron, 39.85.

2. Iron ore on Hamilton Place, *Nicholas* county, occurs on top of hill in rounded masses. Structure irregularly nodular; texture brittle and somewhat close grained; colour chesnut brown, with blackish spots of a dull, resinous lustre.

Composition in 100 parts.

Per-oxide of iron, - - -	80.75
Alumina, - - - -	1.25
Silica and insoluble matter, -	7.40
Water, - - - -	10.00
Loss, - - - -	0.60

Per cent. met. iron, 56.52.

3. Iron ore in the red shales, above the blue sandstone at Red House shoals, *Kanawha.* Structure compact and somewhat slaty; close grained; colour cinnamon brown, without lustre, except a few glimmering points.

Per-oxide of iron, - - -	58.41
Alumina, - - - -	3.45
Silica and insoluble matter, -	32.44
Water, - - - -	4.50
Loss, - - - -	0.20

4. Iron ore, found on dividing ridge between Eighteen Mile creek and Kanawha river, one mile from latter, back of *Mr. Hervey's*, Kanawha. Structure massive, close grained; fracture somewhat conchoidal; colour dull brown, with glimmering micaceous points.

Composition in 100 parts.

Per-oxide iron, - - -	83.00
Alumina, - - - -	5.45
Ox. manganese, - - -	0.25
Silica and insoluble matter, -	10.90
Loss, - - - -	0.40

Per cent. metallic iron, 58.10.

5. Iron ore from the Chesterfield coal basin. Structure massive, somewhat slaty; texture coarse; colour brownish black, with glimmering quartzose points.

Composition in 100 parts.

Per-oxide of iron, - - -	66.00
Alumina, - - - -	7.10
Silica and insoluble matter, -	14.30
Water, - - - -	12.50
Loss, - - - -	0.10

Per cent. met. iron, 46.20.

SECTION XI.

COALS OF THE CHESTERFIELD, POWHATAN, GOOCHLAND AND HENRICO BASINS.

The following results have reference chiefly to a series of specimens collected at an early period of the survey, from workings which in many cases have been discontinued. A still ampler suite of all the coals of this region, collected more recently, and now under examination, will furnish an additional body of details, sufficient, when connected with those now given, to illustrate fully the chemical character and economical value of all the coal seams of this portion of the state.

COALS FROM SOUTH SIDE OF JAMES RIVER.

1. Coal from Stonehenge. Colour of ash, light reddish.

Carbon, - - -	58.70
Volatile matter, - - -	36.50
Ash, - - -	4.80

2. Coal from Engine shaft, Maidenhead. Colour of ash, strong red.

Carbon, - - -	63.97
Volatile matter, - - -	32.83
Ash, - - -	3.20

3. Coal from Engine shaft, worked by *Heth, Potts & Co.*; colour of ash, reddish yellow.

Carbon, - - -	62.35
Volatile matter, - - -	37.65
Ash, - - -	2.80

4. Coal from *Mills & Reid's* Creek pit. Colour of ash, buff.

Carbon, - - -	57.80
Volatile matter, - - -	38.60
Ash, - - -	3.60

5. Coal from *Wills's* pit. Colour of ash, light brown.

Carbon, - - -	62.90
Volatile matter, - - -	32.50
Ash, - - -	4.60

6. Coal from Greenhole shaft. Colour of ash, light red.

Carbon, - - -	67.83
Volatile matter, - - -	30.17
Ash, - - -	2.00

7. Coal from *Col. Heth's* deep shaft, where the explosion occurred. The seam is between thirty and forty feet in thickness. These specimens were selected for analysis, and gave the following results:

Specimen from the *bottom* of the seam. Colour of ash, light pinkish brown.

Carbon, - - -	53.36
Volatile matter, - - -	35.82
Ash, - - -	10.82

Specimen from the *middle* of the seam. Colour of ash, light brownish yellow.

Carbon, - - -	66.50
Volatile matter, - - -	28.40
Ash, - - -	5.10

Specimen from the *top* of the seam. Colour of ash, light pink, inclining a little to brown.

Carbon, - - -	61.68
Volatile matter, - - -	28.80
Ash, - - -	9.52

8. Coal from Powhatan pits, formerly worked by *Capt. Finney*. Colour of ash, pale buff.

Carbon, - - -	59.87
Volatile matter, - -	32.33
Ash, - - -	7.80

COALS FROM NEAR THE APPOMATOX RIVER.

The successful explorations of *Mr. Cox*, on Winterpock creek, near the southern termination of the Chesterfield basin, have of late given great interest to this portion of the coal field. The quality of the coal at *Mr. Cox's* opening, as indicated by analysis, and proved by its use in the grate, is such as to ensure its extensive employment, and combined with the favourable attitude of the seam, and its ample thickness and extent, cannot fail to confer much importance upon this part of the basin.

The following analysis will convey an idea of the composition of the coal. Additional chemical examinations are still required to give a fair average of the several varieties found in this portion of the field.

9. Coal from *Mr. Cox's* mine, Winterpock creek.

Carbon, - - -	65.52
Volatile matter, - - -	29.12
Ash, - - -	5.36

COALS FROM NORTH SIDE OF JAMES RIVER.

10. Coal from *Capt. Thomas M. Randolph's.* Colour of ash, light red.

Carbon,	-	-	-	66.15
Volatile matter,	-	-	-	30.50
Ash,	-	-	-	3.35

11. Coal from Coalbrook dale. Second seam. Colour of ash, light grey.

Carbon,	-	-	-	66.48
Volatile matter,	-	-	-	29.00
Ash,	-	-	-	4.52

12. Coal from *Anderson's* pit. First seam in shaft where the upper seam only was wrought in 1836. Colour of ash, light grey.

Carbon,	-	-	-	66.78
Volatile matter,	-	-	-	28.30
Ash,	-	-	-	4.92

13. Coal from *Barr's* pits. *First seam.* Colour of ash, faint red.

Carbon,	-	-	-	70.80
Volatile matter,	-	-	-	24.00
Ash,	-	-	-	5.20

14. Coal from *Barr's* pits. *Second seam.* Colour of ash, strong red.

Carbon,	-	-	-	54.97
Volatile matter,	-	-	-	22.83
Ash,	-	-	-	22.20

15. Coal from *Barr's* pits. *Third seam.* Colour of ash, light brown.

Carbon,	-	-	-	65.50
Volatile matter,	-	-	-	24.70
Ash,	-	-	-	9.80

16. Coal from *Barr's* pits. *Fourth seam.* Colour of ash, strong red.

Carbon,	-	-	-	56.07
Volatile matter,	-	-	-	21.33
Ash,	-	-	-	22.60

17. Coal from *Crouch's* lower shaft. Upper seam 110 feet beneath surface.

Carbon,	-	-	-	64.60
Volatile matter,	-	-	-	30.00
Ash,	-	-	-	5.40

18. Coal from *Scott's* pit, formerly *Woodward's.* Colour of ash, light grey.

Carbon,	-	-	-	60.86
Volatile matter,	-	-	-	33.70
Ash,	-	-	-	5.44

19. Coal from Waterloo shaft.

Carbon,	-	-	-	55.20
Volatile matter,	-	-	-	26.80
Ash,	-	-	-	18.00

20. Coal from the Deep run pits.

Carbon,	-	-	-	69.84
Volatile matter,	-	-	-	25.16
Ash,	-	-	-	5.00

COKE FROM CHESTERFIELD.

This curious material, occurring in a very heavy bed at the eastern margin of the basin, towards the river, has the aspect and composition of a coal which has been in great part deprived of its volatile ingredients by heat, accompanied by such a pressure of the overlying strata as would prevent the puffy cellular texture usually assumed by coke. Its geological position, and the probable agencies to which it owes its present form, will claim a detailed illustration at a future time. For the present I may remark, that retaining all the carbon of the original coal, this material has great value as a combustible, yielding the intense and steady heat of anthracite, at the same time that from its less compact texture, it is more readily ignited than coal of that description. The following is the composition of 100 grains of the more compact variety:

Carbon, - - -	80.30
Volatile matter, - - -	9.98
Ash, - - -	9.72

GLOSSARY

OF GEOLOGICAL AND OTHER SCIENTIFIC TERMS.

FROM LYELL'S PRINCIPLES OF GEOLOGY.

Alluvium.—Earth, sand, gravel, stones, and other transported matter which has been washed away and thrown down by rivers, floods, or other causes, upon land not *permanently* submerged beneath the waters of lakes or seas.

Amorphous.—Bodies devoid of regular form.

Amygdaloid.—One of the forms of the Trap-rocks, in which agates aad simple minerals appear to be scattered like almonds in a cake.

Analcime.—A simple mineral of the Zeolite family, also called Cubizite, of frequent occurrence in the Trap-rocks.

Anticlinal Axis.—If a range of hills, or a valley, be composed of strata, which on the two sides dip in opposite directions, the imaginary line that lies between them, towards which the strata on each side rise, is called the anticlinal axis. In a row of houses with steep roofs facing the south, the slates represent inclined strata dipping north and south, and the ridge is an east and west anticlinal axis.

Arenaceous.—Sandy.

Argillaceous.—Clayey, composed of clay.

Arragonite.—A simple mineral, a variety of carbonate of lime, so called from having been first found in Arragon, in Spain.

Augite.—A simple mineral of a dark green or black colour, which forms a constituent part of many varieties of volcanic rocks.

Basalt.—One of the most common varieties of the Trap-rocks. It is a dark green or black stone, composed of augite and felspar, very compact in texture, and of considerable hardness, often found in regular pillars of three or more sides, called basaltic columns. Remarkable examples of this kind are seen at the Giant's Causeway, in Ireland, and at Fingal's Cave, in Staffa, one of the Hebrides. The term is used by Pliny, and is said to come from *basal*, an Æthiopian word signifying iron. The rock often contains much iron.

"*Basin*" of Paris, "*Basin*" of London.—Deposites lying in a hollow or trough, formed of older rocks, sometimes used in geology almost synonymously with "formations," to express the deposites lying in a certain cavity or depression in older rocks.

Belemnite.—An extinct genus of the order of molluscuous animals called Cephalopoda, having a long, straight and chambered conical shell.

Bitumen.—Mineral pitch, of which the tar-like substance which is often seen to ooze out of the Newcastle coal when on the fire, and which makes it cake, is a good example.

Bituminous Shale.—An argillaceous shale, much impregnated with bitumen, which is very common in the coal measures.

Blende.—A metallic ore, a compound of the metallic zinc with sulphur. It is often found in brown shining crystals, hence its name among the German miners, from the word *blenden*, to dazzle.

Botryoidal.—Resembling a bunch of grapes.

Bowlders.—A provincial term for large rounded blocks of stone lying on the surface of the ground, or sometimes imbedded in loose soil, different in composition from the rocks in their vicinity, and which have been therefore transported from a distance.

Breccia.—A rock composed of angular fragments connected together by lime or other mineral substance. An Italian term.

Calc Sinter.—A German name for the deposites from springs holding carbonate of lime in solution—petrifying springs.

Calcareous Rock.—Limestone.

Calcareous Spar.—Crystallized carbonate of lime.

Calcedony.—A silicious simple mineral, uncrystallized. Agates are partly composed of calcedony.

Carbon.—An undecomposed inflammable substance, one of the simple elementary bodies. Charcoal is almost entirely composed of it.

Carbonate of Lime.—Lime combines with great avidity with carbonic acid, a gaseous acid only obtained fluid when united with water,—and all combinations of it with other substances are called *Carbonates.* All limestones are carbonates of lime, and quick lime is obtained by driving off the carbonic acid by heat.

Carbonic Acid Gas.—A natural gas which often issues from the ground, especially in volcanic countries.

Carboniferous.—A term usually applied, in a technical sense, to an ancient group of secondary strata, but any bed containing coal may be said to be carboniferous.

Cephalopoda.—A class of molluscous animals, having their organs of motion arranged round their head.

Cetacea.—An order of vertebrated mammiferous animals inhabiting the sea. The whale, dolphin, and narwal, are examples.

Chalk.—A white earthy limestone, the uppermost of the secondary series of strata.

Chert.—A silicious mineral, nearly allied to calcedony and flint, but less homogeneous and simple in texture. A gradual passage from chert to limestone is not uncommon.

Chloritic Sand.—Sand coloured green by an admixture of the simple mineral chlorite.

Clinkstone, called also *Phonolite*, a felspathic rock of the Trap family, usually fissile. It is sonorous when struck with a hammer, whence its name.

Coal Formation.—This term is generally understood to mean the same as the Coal Measures. There are, however, "coal formations" in all the geological periods, wherever any of the varieties of coal form a principal constituent part of a group of strata.

Conformable.—When the planes of one set of strata are generally parallel to those of another set which are in contact, they are said to be conformable.

Conglomerate or *Puddingstone.*—Rounded water-worn fragments of rock or pebbles, cemented together by another mineral substance, which may be of a siliceous, calcareous, or argillaceous nature.

Coniferæ.—An order of plants which, like the fir and pine, bear cones or tops, in which the seeds are contained.

Crag.—A provincial name in Norfolk and Suffolk for a deposite, usually of gravel, belonging to the Older Pliocene period.

taceous.—Belonging to chalk.

Crop Out.—A miner's or mineral surveyor's term, to express the rising up or exposure at the surface of a stratum or series of strata.

Crustacea.—Animals having a shelly coating or crust, which they cast periodically. Crabs, shrimps and lobsters are examples.

Cryptogamic.—A name applied to a class of plants, such as ferns, mosses, sea-weeds, and fungi, in which the fructification or organs of reproduction are concealed.

Crystalline.—The internal texture which regular crystals exhibit when broken, or a confused assemblage of ill-defined crystals. Loaf sugar and statuary marble have a *crystalline* texture. Sugar candy and calcareous spar are crystallized.

Debacle.—A great rush of waters, which, breaking down all opposing barriers, carries forward the broken fragments of rocks, and spreads them in its course.

Delta.—When a great river, before it enters the sea, divides into separate streams, they often diverge and form two sides of a triangle, the sea being the base. The land included by the three lines, and which is invariably alluvial, was first called, in the case of the Nile, a delta, from its resemblance to the letter of the Greek alphabet which goes by that name. Geologists apply the term to alluvial land formed by a river at its mouth, without reference to its precise shape.

Denudation.—The carrying away by the action of running water of a portion of the solid materials of the land, by which inferior rocks are laid bare.

Dykes.—When a mass of the unstratified or igneous rocks, such as Granite, Trap, and Lava, appears as if injected into a great rent in the stratified rocks, cutting across the strata, it forms a dyke; and as they are sometimes seen running along the ground, and projecting, like a wall, from the softer strata on both sides of them having wasted away, they are called in the north of England and in Scotland *dykes*, the provincial name for wall. It is not easy to draw the line between dykes and veins. The former are generally of larger dimensions, and have their sides parallel for considerable distances; while veins have generally many ramifications, and these often thin away into slender threads.

Diluvium.—Those accumulations of gravel and loose materials which, by some geologists, are said to have been produced by the action of a diluvian wave or deluge sweeping over the surface of the earth.

Dip.—When a stratum does not lie horizontally, but is inclined, the point of the compass towards which it sinks is called the dip of the stratum, and the angle it makes with the horizon is called the angle or dip of inclination.

Dolerite.—One of the varieties of the Trap rocks, composed of Augite and Felspar.

Dolomite.—A crystalline limestone, containing magnesia as a constituent part. Named after the French geologist Dolomieu.

Dunes.—Low hills of blown sand that skirt the shores of Holland, England, Spain, and other countries.

Eocene.—The great Tertiary era is divided into four periods, the first of which is called *Eocene*, indicating that in the beds of this division, we see the first traces or *dawn* of the present order of things. The class of fossils most serviceable in determining the relations of the existing to the extinct species, are *shells*, and it is between these, more particularly, that the comparison has been made. Out of about 1200 shells discovered in Europe in this lower division of the Tertiary rocks, 38 only are identical with species known to be living. This small proportion (about 3 per cent.)

varies a little, of course, with the deposites of different regions; and the deposites of this formation, like those of any other, are characterized less by the *precise* proportion of their extinct fossils, than by possessing a number of shells peculiar to the particular era, and found in no other Tertiary groups.

Estuaries.—Inlets of the land, which are entered both by rivers and the tides of the sea. Thus we have the Estuaries of the Thames, Severn, Tay, &c.

Fault, in the language of miners, is the sudden interruption of the continuity of strata in the same plane, accompanied by a crack or fissure varying in width from a mere line to several feet, which is generally filled with broken stone, clay, &c.

Felspar.—A simple mineral, which, next to Quartz, constitutes the chief material of rocks. The white angular portions in Granite are Felspar.

Ferruginous.—Any thing containing iron.

Formation.—A group, whether of alluvial deposites, sedimentary strata, or igneous rocks, referred to a common origin or period.

Fossil.—All minerals used to be called fossils, but geologists now use the word only to express the remains of animals and plants found buried in the earth.

Galena.—A metallic ore, a compound of lead and sulphur. It has often the high appearance of highly polished lead.

Garnet.—A simple mineral, generally of a deep red colour, crystallized, most commonly met with in Mica slate, but also in granite and other igneous rocks.

Gault.—A provincial name in the east of England for a series of beds of clay and marl, the geological position of which is between the upper and lower greensand.

Gneiss.—A stratified primary rock, composed of the same materials as Granite, but having usually a larger proportion of Mica, and a laminated texture. The word is a German miner's term.

Granite.—An unstratified or igneous rock, generally found inferior to or associated with the oldest of the stratified rocks, and sometimes penetrating them in the form of dykes and veins. It is usually composed of three simple minerals, Felspar, Quartz, and Mica, and derives its name from having a coarse *granular* structure.

Graywacke.—*Grauwacke*, a german name, generally adopted by geologists for the lowest members of the secondary strata. The rock is very often of a gray colour, hence the name *grau*, being German for gray, and *wacke* being a provincial miner's term.

Greensand.—Beds of sand, sandstone, limestone, belonging to the Cretaceous period. The name is given to these beds because they often, but not always, contain an abundance of green earth or chlorite scattered through the substance of the sandstone, limestone, &c.

Greenstone.—A variety of Trap, composed of Hornblende and Felspar.

Grit.—A provincial name for a coarse grained sandstone.

Gypsum.—A mineral composed of lime and sulphuric acid, hence called also *sulphate* of *lime.* Plaster and stucco are obtained by exposing gypsum to a strong heat. It is found so abundantly near Paris, that Paris plaster is a common term in this country for the white powder of which casts are made. The term is used by Pliny for a stone used for the same purposes by the ancients. The derivation is unknown.

Hornblende.—A simple mineral of a dark green or black colour, which enters largely into the composition of several varieties of the Trap rocks.

Hornstone.—A silicious mineral substance sometimes approaching nearly to flint, or common Quartz. It has a conchoidal fracture, and is infusible, which distinguishes it from compact Felspar.

Jura Limestone.—The limestones belonging to the oolitic group, constitute the chief part of the mountains of the Jura, between France and Switzerland, and hence the geologists of the continent have given the name to the group.

Laminæ.—Latin for plates; used in geology for the smaller layers of which a stratum is frequently composed.

Lava.—The stone which flows in a melted state from a volcano.

Lias.—A provincial name, adopted in scientific language, for a particular kind of limestone, which, being characterized together with its associated beds, by peculiar fossils, forms a particular group of the secondary strata.

Lignite.—Wood converted into a kind of coal.

Lithological.—A term expressing the stony structure or character of a mineral mass. We speak of the lithological character of a stratum as distinguished from its zoological character.

Littoral.—Belonging to the shore.

Loam.—A mixture of sand and clay.

Madrepore.—A genus of corals, but generally applied to all the corals distinguished by superficial star-shaped cavities. There are several fossil species.

Mammillary.—A surface which is studded over with rounded projections.

Mammoth.—An extinct species of the elephant, of which the fossil bones are frequently met with in various countries. The name is of Tartar origin, and is used in Siberia for animals that burrow under ground.

Marl.—A mixture of clay and lime; usually soft, but sometimes hard, in which case it is called indurated marl.

Mastodon.—A genus of fossil extinct quadrupeds allied to the elephant. So called from the form of the hind teeth or grinders, which have their surface covered with conical mammillary crests.

Matrix.—If a simple mineral or shell, in place of being detached, be still fixed in a portion of rock, it is said to be in its matrix. *Matrix*, womb.

Mechanical Origin, Rocks of.—Rocks composed of sand, pebbles, or fragments, are so called, to distinguish them from those of a uniform crystalline texture, which are of chemical origin.

Mica.—A simple mineral, having a shining silvery surface, and capable of being split into very thin elastic leaves or scales. It is often called *talc* in common life, but mineralogists apply the term talc to a different mineral. The brilliant scales in granite are mica.

Mica-Slate, Mica-Schist, Micaceous Schistus.—One of the lowest of the stratified rocks, belonging to the hypogene or primary class, which is characterized by being composed of a large proportion of mica, united with quartz.

Meiocene.—This is the period next succeeding the eocene, and embraces a larger share of recent or living species among the organic remains. Out of 1021 shells in Europe, 176 only belong to animals now living, making the proportion of the recent species about 18 per cent.

Mollusca, Molluscous Animals.—Animals, such as shell-fish, which, being devoid of bones, have soft bodies.

Mountain Limestone.—A series of limestone strata, of which the geological position is immediately below the coal-measures, and with which they also sometimes alternate.

Muriate of Soda.—The scientific name for common culinary salt, because it is composed of muriatic acid and the alkali soda.

New Red Sandstone.—A series of sandy, argillaceous, and often calcareous strata, the predominant colour of which is brick-red, but containing portions which are of a greenish grey. These occur often in spots and stripes, so that the series has sometimes been called the variegated sandstone. The European formation so called lies in a geological position immediately above the coal-measures.

Nodule.—A rounded irregular shaped lump or mass.

Old Red Sandstone.—A stratified rock belonging to the Carboniferous group (of Europe.)

Oolite, Oolitic.—A limestone, so named because it is composed of rounded particles, like the roe or eggs of a fish. The name is also applied to a large group of strata, characterized by peculiar fossils, because limestone of this kind occurs in this group in England, France, &c.

Organic Remains.—The remains of animals and plants (*organized* bodies) found in a fossil state.

Orthocerata, or *Orthoceræ.*—An extinct genus of the order of Molluscous animals, called Cephalopoda, that inhabited a long chambered conical shell, like a straight horn.

Outliers.—When a portion of a stratum occurs at some distance, detached from the general mass of the formation to which it belongs, some practical mineral surveyors call it an *outlier*, and the term is adopted in geological language.

Oxide.—The combination of a metal with oxygen; rust is oxide of iron.

Oxygen.—One of the constituent parts of the air of the atmosphere; that part which supports life. For a farther explanation of the word, consult elementary works on chemistry.

Pelagian, *Pelagic.*—Belonging to the *deep* sea.

Petroleum.—A liquid mineral pitch, so called because it is seen to ooze like oil out of the rock.

Pisolite.—A stone possessing a structure like an agglutination of peas.

Pit Coal.—Ordinary coal; called so because it is obtained by sinking pits in the ground.

Pitch Stone.—A rock of a uniform texture, belonging to the unstratified and volcanic classes, which has an unctuous appearance like indurated pitch.

Pliocene.—This is founded upon the existence, in the beds which it embraces, of a *greater* number of recent than extinct species. The pliocene rocks are referred to two periods, the Older Pliocene and Newer Pliocene. In the newer pliocene, the number of extinct species is extremely small.

Plutonic Rocks.—Granite, porphyry, and other igneous rocks, supposed to have consolidated from a melted state at a great depth from the surface.

Porphyry.—An unstratified or igneous rock. The term is as old as the time of Pliny, and was applied to a red rock with small angular white bodies diffused through it, which are crystallized felspar, brought from Egypt. The term is hence applied to every species of unstratified rock in which detached crystals of felspar are diffused through a base of other mineral composition.

Precipitate.—Substances which having been dissolved in a fluid, are separated from it by combining chemically and forming a solid which falls to the bottom of the fluid. This process is the opposite to that of chemical solution.

Producta.—An extinct genus of fossil bivalve shells, occurring only in the older secondary rocks. It is closely allied to the living genus Terebratula.

Pyrites. (Iron.)—A compound of sulphur and iron, found usually in yellow shining crystals like brass, and in almost every rock stratified and unstratified. The shining metallic bodies, so often seen in common roofing slate, are a familiar example of the mineral.

Quartz.—A German provincial term, universally adopted in scientific language, for a simple mineral composed of pure silex, or earth of flints: rock-crystal is an example.

Sandstone.—Any stone which is composed of an agglutination of grains of sand, whether calcareous, silicious, or of any other mineral nature.

Saurian.—Any animal belonging to the lizard tribe.

Schist.—Synonymous with slate.

Seams.—Thin layers which separate two strata of greater magnitude.

Secondary Strata.—An extensive series of the stratified rocks which compose the crust of the globe, with certain characters in common, which distinguish them from another series below them, called *primary*, and from a third series above them called *tertiary*.

Sedimentary Rocks, are those which have been formed by their materials having been thrown down from a state of suspension or solution in water.

Selenite.—Crystallized gypsum, or sulphate of lime—a simple mineral.

Serpentine.—A rock usually containing much magnesian earth, for the most part unstratified, but sometimes appearing to be an altered or metamorphic stratified rock. Its name is derived from frequently presenting contrasts of colour, like the skin of some serpents.

Shale.—A provincial term, adopted by geologists to express an indurated slaty clay.

Shell Marl.—A deposite of clay, peat, and other substances mixed with shells, which collects at the bottom of lakes.

Shingle.—The loose and completely water-worn gravel on the seashore.

Silex.—The name of one of the pure earths, being the Latin word for *flint*, which is wholly composed of that earth. French geologists have applied it as a generic name for all minerals composed entirely of that earth, of which there are many of different external forms.

Silicious.—Of or belonging to the earth of flint. A silicious rock is one mainly composed of silex.

Silt.—The more comminuted sand, clay, and earth, which is transported by running water. It is often accumulated by currents in banks. Thus the mouth of a river is silted up when its entrance into the sea is impeded by such accumulation of loose materials.

Simple Mineral.—Individual mineral substances, as distinguished from the rocks, which last are usually an aggregation of simple minerals. They are not simple in regard to their nature, for, when subjected to chemical analysis, they are found to consist of a variety of different substances. Pyrites is a simple mineral in the sense we use the term, but it is a chemical compound of sulphur and iron.

Stalactite.—When water holding lime in solution deposites it as it drops from the roof a cavern, long rods of stone hang down like icicles, and these are called *stalactites*.

Stalagmite.—When water holding lime in solution drops on the floor of a cavern, the water evaporating leaves a crust composed of layers of limestone: such a crust is called *stalagmite*.

Stilbite.—A crystallized simple mineral, usually white, one of the Zeolite family, frequently included in the mass of the Trap rocks.